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OBSERVATIONS ON TWO FORMS OF STERILITY IN RICE

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SEVEN PLATES AND TWO TEXT FIGURES

Sterility in rice means the failure to produce grains. In a broad sense it implies the occurrence of undeveloped or abnormally small flowers, or the appearance of empty or imperfect grains in the panicle, either partial or complete, brought about by unfavorable weather or environmental conditions, defective reproductive organs, genetic incompatibility, parasitic fungi, insect pests, or other factors. A combination of two or more of these factors, however, may at times be responsible for the incidence of sterility.

Sterility is one of the causes of poor rice yields in the Philippines, and knowledge concerning it would be of practical value to the rice grower. In the present paper we place on record the extent of damage resulting from the two conditions of rice sterility here described. On kind of sterility has been often found in rice fields, occurring naturally year after year in more or less varying degrees of severity, but apparently has attracted little or no attention. The other kind is less perceptible and is brought about by the cross-fertilization of divergent types, or of parents possessing incompatible genetic qualities, or it

may be inherited from forms producing abortive spikelets in more or less varying degree, and may arise spontaneously and remain true to type. For convenience we might call the first "white sterility" and the second "cross sterility." Notes and field observations are also given.

HISTORY, DISTRIBUTION, AND ECONOMIC IMPORTANCE

Undoubtedly sterility in rice occurred in the early history of rice cultivation in this country. In the year 1912, Borja noticed among several varieties in plot culture in the Alabang Rice Experiment Station, Rizal Province, Luzon, one which exhibited a white, turfy appearance at the terminal portion of some panicles in a considerable number of plants. The characteristic defect of terminal glumes has reoccurred in a more or less varying degree of severity in succeeding generations and is seemingly a true hereditary character.

The earliest official communications regarding the occurrence of rice white sterility were addressed by Mr. Hilary P. Clapp to the Bureau of Science and were dated June 16 and 26, 1920. Mr. Clapp then stated that the trouble, as it appeared in the Mountain Province, was of a very serious nature, affecting considerably the flowering of rice in and around Trinidad Valley, which has an altitude of about 4,000 feet above sea level. It was so severe at that time, the informant further stated, that it was quite impossible to find a sound panicle in the fields! He allayed the fears of the farmers in that region by estimating a probable loss of 25 per cent of the rice crop. For lack of a better term, the trouble was provisionally referred to as the "Trinidad disease," by H. A. Lee, then mycologist of the Bureau of Science.

In a brief personal inquiry and observation made by Reyes about the end of June, 1920, white sterility was found uniformly distributed and was very noticeable in the rice fields, and information was further obtained from Mr. J. A. Wright and Mr. Flores, principal and teacher, respectively, of the Trinidad Farm School, to the effect that it was the first appearance of the "disease" in Trinidad Valley, although the natives who had been growing rice there claimed to had observed it in previous years. The latter information seems to the writers authentic because the farm school had then been growing rice for only two seasons, and the seeds were believed to have been obtained originally from Bontoc where rice has long been cultivated. As

no counts were made of sterile flowers in any population, the actual amount of damage was not known. The partial sterility, however, shown in the accompanying plates, taken from representative specimens, gives some idea of the proportion of sterile spikelets. In the Twentieth Annual Report of the Bureau of Science, for the year ending December 31, 1921, a serious "disease" of rice causing sterile heads was reported as occurring in the Mountain Province, which most likely refers to the same defect. In 1932, the loss from this sterile condition in the lowlands at Alabang, Rizal Province, was carefully estimated from affected varieties grown in plots under the same conditions, and it varied on an average of from 14.43 to 24.40 per cent.

In past years, a similar form of sterility was observed in Rizal, Cavite, Tarlac, and other provinces, and reports of its occurrence were received from Cotabato Province. In none of these regions, however, was the injury so great as that found in the terraces and plains of the high altitudes. In India, Bhide(1) reported, in 1922, the incidence of this form of sterility in rice flowers, and later Ramiah,(5) in 1931. In Coimbatore, 2 to 40 per cent sterility had been observed by Ramiah in pure lines.

Regarding the presence of sterility in rice, Terao(8) in 1921, Suzuta and Suematu,(7) and Ishikawa,(2) in 1927, reported the occurrence in Japan of semisterility in rice plants in the ratio of 1 : 1. Nagai(4) in 1926, also gave an account of partial sterility in rice in that country, resulting in a 1 : 1 ratio. In the experiments of Ishikawa,(2) it was found that partially sterile plants produced fertile and sterile offspring in the ratio of 7 : 1, but in semisterile plants, the split was in the ratio of 1 : 1.

Sterility in three natural hybrids has been observed in the Alabang Rice Experiment Station by Torres(9) in the Gopher variety, and on artificial hybrids of Storm Proof ♀ x Apostol ♂, and Baladong ♀ x Apostol ♂. These hybrids were studied to determine whether the sterility was inherited.

In the 1931-1932 rice season, the incidences of sterility were also observed at the Alabang Rice Experiment Station, Rizal Province, in certain artificial crosses made to produce desirable new types. The most notable of these were between varieties having marked contrasting characters, as between Ramay ♀[1] x Inadhica ♂ and Elon-elon ♀[2] x Inadhica ♂ (Plate 5), which

[1] A variety introduced from French Indo-China.

[2] Believed to be a Chinese variety, but named after the importer.

showed in actual counts of filled and empty spikelets of panicles selected at random from ten plants in F_3 and F_2 generations, a range of from 8.8 to 31.5 per cent and 20.3 to 60.3 per cent, or an average of 16.5 per cent and 30.9 per cent, respectively. It should be remarked that Inadhica, one of the parent varieties, normally exhibits a large percentage of sterility, amounting to 25 per cent in round numbers. There are other varieties showing similar characteristics, which suggests that they are probably of hybrid origin.

According to Bhide,(1) an artificial hybrid between a starchy variety called "botka" and "black" rice, a glutinous type, gave complete sterility in F_1, which exhibited an unusually heavy vegetative growth. In a cross between pure lines, Ramiah(5) observed as much as 95 per cent sterility, but this he was inclined to think a mutant. The same author states that sterility was markedly manifest in hybrids produced by crossing varieties having wide varietal characteristics, such as length of maturity, tillering habit and size of grains, and that in parents where practically no sterility has been observed, 4 to 56 per cent sterility resulted in the F_2 generations. As cited by this author(5) Jones, in the United States, also made reference to this kind of sterility in the first generation hybrids, and in progenies resulting by crossing Chinese and Japanese rice varieties. In the investigation of Kato et al.(3) in Japan, it was demonstrated that crosses of varieties of similar morphological characters gave high fertility, amounting to 68.7 per cent in their F_1 plants, whereas the hybrids of crosses between different types gave a low fertility of about 14 per cent. The corresponding figures for the F_2 plants are 80.9 and 26.2 per cent.

DESCRIPTIONS OF RICE STERILITY

The first kind of sterility in the inflorescence of rice for which the name "white sterility" is proposed by the writers, is characterized by the presence usually at the terminal portions of the panicle (Plates 1 and 3) of abnormally small, empty, white spikelets occurring in groups, but these may also be found in or about the middle or the base (Plates 1 and 4), or anywhere else in the panicle (Plate 2), presenting a very marked contrast with the normal flowers. As the normal grains ripen these sterile rudimentary spikelets shrivel up and drop off, leaving sometimes traces of the barren stalks on the panicle (Plate 4, fig. 2). The number of glumes affected in a panicle varies. This kind of sterility should not be confused with the pseudo-

sterility caused by stem borers (larvæ of a small moth, *Schoenobius incertellus* Walker), or by a small, brown rice grasshopper, a species of the genus *Catantops* [3], which can be readily distinguished by the "white heads" ("uban" in Tagalog), so called on account of the stiff white appearance that the whole panicle exhibits when all the flowers glumes are empty and closely compacted to the rachis.

Cross sterility, on the other hand, is readily recognized by the occurrence in an otherwise normal panicle of single empty flower glumes or abortive spikelets, scattered more or less uniformly among well-developed grains. In the first stages of development they are not easily detected, but they become obviously manifest as the panicle matures (Plates 5, 6, and 7). The fertile flowers assume their normal color gradually as they ripen, while the sterile ones remain greenish for some time and then change to a pale straw color. In dark-colored hybrids or in those whose glumes have shades deviating from the straw color on maturity, there is a clearer distinction between sterile and fertile grains (Plate 5).

CAUSES OF RICE STERILITY

The white sterility herein described has been attributed to a variety of causes. Many purely hypothetical conjectures have been made some of which merit serious consideration. Among peasants and hill tribes the cause is ascribed to certain superstitions. The most reasonable beliefs revealed in conferences held with rice planters and others familiar with rice growing are that sterility is due to unfavorable weather conditions or to physiological disturbance in the rice plant, or that it is a morphological defect in the flower resulting in nonfertilization. Others think that it is due to the attack of some fungous disease or insect pest. It is not, however, the purpose of this article to prove or disprove all these theories.

Fresh specimens examined both macroscopically and microscopically disclosed nothing in their general appearance, roots, stems, and all that would lead to any probable pathological or entomological diagnosis. The affection does not spread or extend to the healthy unaffected parts of the panicles, so that we can be sure that it is nonparasitic and not infectious. Isolations made from freshly collected specimens in the early stages, in an effort to grow any possible fungi or bacteria which might be present, have revealed the absence of any one organism which

[3] Identified by Mr. F. Q. Otanes of the Bureau of Plant Industry.

might be the cause. In a very few cases bacteria were obtained in such a small proportion that we were led to believe they were only chance infections or contaminations. In other words no evidence of fungous disease was found and no insect pest was associated with it, so that the theory relative to a fungous disease or an insect pest seems out of the question in so far as our investigation showed.

Weather relations.—Although there is no direct evidence, there is every reason to believe that the trouble is due at least partly to some unfavorable weather or climatic conditions. Rain occurring at the critical period of pollination followed by hot sunshine is responsible for the occurrence of sterility. This weather condition often obtains in October, coincident with the flowering of early varieties of rice in central Luzon, Panay Island, and elsewhere.

Arrested development may be also due to high winds. November 24, 1928, an extraordinary typhoon occurred which hit Alabang, Rizal Province, at the time certain late-maturing varieties, normally fertile, were in the boot stage. As a result the plants lodged and the panicles were partially sterile.

Salmon(6) attributed the low yield of durum wheats to the prevalence of an unusually dry, hot spell during the flowering period in the Great Plains, United States, in 1910 and 1911. To him is also credited the statement that low relative humidity rather than high dryness of air is the main controlling factor. Ramiah(5) stated that the opening of the rice glumes and the dehiscence of the anthers are greatly influenced by the air temperature and moisture prevailing. So that when blooming takes place during high and dry atmospheric temperature, the anther sacs shrink and do not dehisce. A similar phenomenon has been repeatedly observed at the Alabang Rice Experiment Station in panicles bagged with paraffin paper for selfing or other purposes, in which the moisture and temperature conditions created within the bag generally proved detrimental to the anthers and consequently to successful fertilization.

The planting of rice in the wrong season is an outstanding example of the deleterious effects of unfavorable weather on grain yield. Ramiah(5) found in tests on the incidence of sterility at different times of sowing, that excessive rainfall during the flowering period, or very dry soil at the time of greatest transpiration, is conducive to sterility. In support of this argument, we might quote what Ramiah has to say: "It is

recognized that every variety of rice has an optimum season, and growing it in the wrong season results in poor yield, one of the contributing causes for such low yields being the occurrence of sterility."

Weather fluctuations are chiefly responsible for the planting of rice in off-seasons in this country. Failure of rain to come at the time the fields are due for plowing causes delay in transplanting, as also when drought comes and dries the fields before the crop can be put in. The result of delayed transplanting is manifested in stunted growth and it may be stated that infertility here is largely a consequence of the weakened constitution of the plants.

In the case of failures of flowers to develop normally due to insufficient moisture in the soil, as when a protracted drought affecting unirrigated crops occurs, we see a general withering, both of vegetative and reproductive parts. A case in point is the Macan China rice grown in Guimba, Nueva Ecija Province, in 1927. In November, that year, some days after the plants had headed out, a drought prevailed, and the crop presented erect panicles with the characteristic pale, greenish white color. Upon examination the glumes were found to be partly open, containing the undeveloped pistil in a semi-dry state.

The condition of heading where only part of the panicles emerges from the leaf sheath is another form of arrested reproductive growth partly due to drought. Here fertilization, if any, succeeds only to a limited extent, so that a more or less high percentage of sterility is evident in such panicles. The variety Inantipolo, for instance, is highly susceptible to this form of partial sterility on account of its peculiar habit of heading out unevenly and at a slow rate. The rapidity at which the plants can send the flower structure out is known to differ with different varieties. Pure line plants selected for uniformity of heading exhibit it to the highest degree, while abortive heading, extremely variable, is common to all exotic unacclimatized varieties.

The foregoing instances include the effects of the physical factors which have come to our notice, although undoubtedly there are some more. It can be easily understood that when drought exerts its effect after fertilization has taken place, the manifestation is quite distinct from white sterility, in that while the pistil development is arrested the floral structure is complete and has assumed its normal color up to the time of withering.

In a typical case of white sterility the glumes are papery and lacking the cilicious nature of the flowers that have attained a certain development, indicating an early formation of the "white flowers" at heading or while the panicle is within the leaf sheath. Elsewhere is described a sort of atrophy in which normal flowers and undersized ones were found in a panicle in the boot stage.

Physiological and morphological relations.—The findings of Ramiah(5) throw some light on this question of rice sterility, in that abortion or arrested development takes place in the anther sacs and the ovaries, and that it has been found to be a varietal character frequently associated with a certain size and arrangement of grains, such as small grains and compact grains in the panicle. The same author asserts that it is a varietal "Mendelian character, simple and recessive to the normal spikelet," and claims that the incidence of terminal sterility can be augmented by excessive applications of manure in the affected rice fields. Too much soil fertility causes the plants to lodge even at the time of flowering, due to rank vegetative growth, resulting in the production of sterile spikelets. The writers are inclined to believe that the failure of fertilization may result from exposure, because the top grains, where pollination usually takes place first, are generally the ones affected. Some cases of sterility, however, were found when the panicles were yet inclosed in the boot, indicating that retarded emergence affects the fertility of the flowers (text fig. 1, *a*, and Plate 4, fig. 1) as already mentioned. Comparing this rice flower affection observed in the Philippines with that occurring in India as reported by Ramiah(5) it is safe to infer that they are closely similar, if not identical.

Morphologically abnormal pollen (text fig. 2, *a* to *c* and *e*) is said to be a common cause of sterility in rice. Also, when stigmas do not develop at the same time as the anthers, they remain inside the glumes and when the flower glumes close they miss the reception of the pollen. Sterility may be due sometimes to defective stigmas (text fig. 1, *b*) and ovaries or to an abnormal arrangement of the flower structure. Bhide(1) reported that he had found in a variant collapsed and nonviable pollen grains which had little or no contents and that the pollen and anthers did not show their natural yellow color, while although the ovary was apparently normal, no grain developed. Suzuta and Suematu(7) claimed to have often seen in semisterile

paddy rice plants embryoless seeds, or water taking the place of the endosperm. The findings of Bhide we have confirmed in the Philippines (text fig. 2), and they revealed the following facts:

All examinations of sterile florets were made from fresh panicles of Guinangang Str. 1, which had not yet emerged from the boot. Those found at the tips were generally much smaller than those found at the lower laterals and were all white, becoming slightly twisted or curved on exposure to dry atmosphere. Some defective florets occurring at the base of panicles were also white, but the apical and basal portions of the inner glumes had a greenish tint. Sometimes the nerves were also greenish. They contained the essential organs (text fig. 1, *b*) of normal flowers, but the stigmas seemed to be less feathery or not well developed and not freely exposed. Anthers having a pale yellow color obtained from fifteen chartaceous flowers when burst showed, on microscopic examination, pollen grains having little or no contents (text fig. 2, *a*), and fewer in number than those found in the normal anthers; while those from twenty-

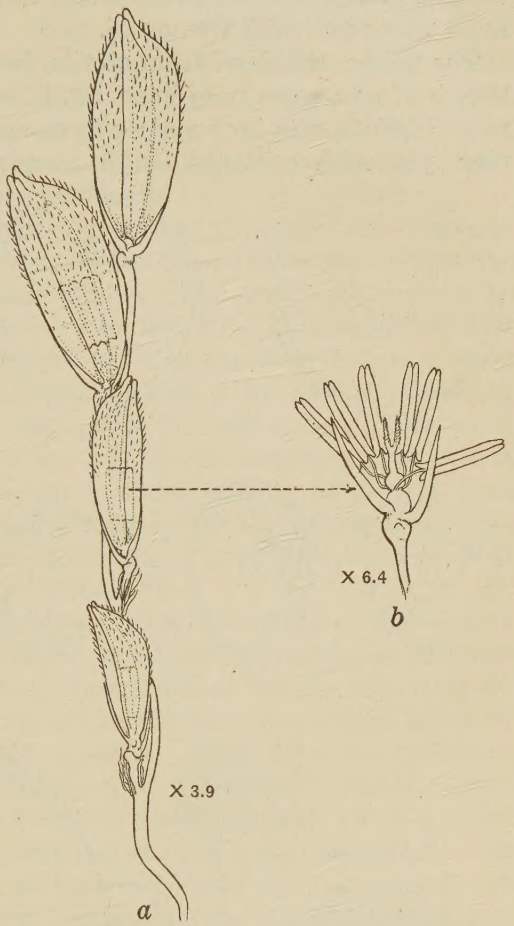

FIG. 1. *a*, Portion of a rice spike of Guinangang Str. 1, obtained from a panicle still within the barrel, to show the comparative sizes of normal and sterile flowers, approximately x 3.9. *b*, Reproductive organs obtained from the third flower shown in *a*, possessing all the essential organs but having somewhat less feathery or poorly developed stigmas and the filaments of the abortive stamens not fully extended, about × 6.4.

eight dimunitive white flowers having white or slightly yellowish anthers contained no pollen at all. The proportion of undeveloped flowers having pollen to those without any pollen (usually from white anthers) was 6 : 25.

The pollen dislodged from sterile flowers is more or less hyaline, having a germ pore (text fig. 2, *a-c* and *e-f*) or rarely two in each grain, and they appear to be empty or without the granular, yellowish contents found in normal pollen grains (text

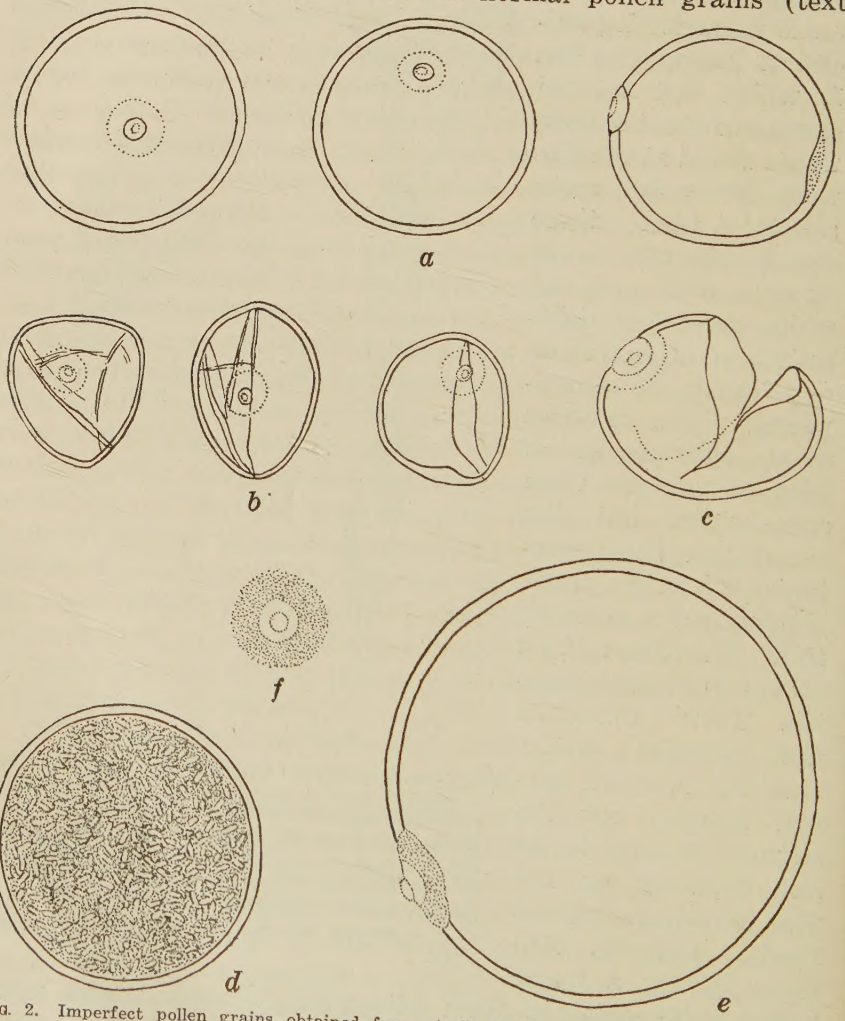

FIG. 2. Imperfect pollen grains obtained from sterile florets of the same variety, drawn with a camera lucida to show morphological structures: *a*, Fresh pollen grains without contents; *b*, shriveled pollen grains assuming various shapes; *c*, a burst pollen grain, × 653; *d*, normal pollen grain to show the difference, × 653; *e*, a highly magnified sterile pollen grain without contents, showing the germ pore at the periphery, × 1,300; *f*, a front view of the germ pore × 1,300.

fig. 2, *d*) ; hence, nonfunctional. These imperfect pollen grains are approximately of the same shape (text fig. 2, *a*), fewer in number than the grains in normal flowers, and are undersized, some being very small. They easily collapse (text fig. 2, *b*) for lack of the necessary contents and probably due to rapid shrinkage, or else they are weakly developed. However, pollen grains with scanty content were few in number. Pollen from sterile florets does not germinate, as found by tests made even with the use of different media.

For purposes of comparison, normal pollen grains were also studied. They were variable in size but fairly round and regular in shape. Under the microscope they exhibited a granular substance having a yellowish tint and were rather thick walled (text fig. 2, *d*). When they burst the granular contents, which were elongated bodies measuring 1.42 μ by 4.28 μ, came out. There was at least one germ pore in each pollen grain, made visible when the contents are forced out, measuring about 3.99 μ in diameter on the average. Water mounts of normal fresh pollen grains measure from 36.05 microns to 57.0 microns, while the grains obtained from undeveloped flowers are from 34.20 microns to 55.57 microns in diameter.

Genetic relations.—The second form of sterility discussed here, or cross sterility, is believed to be a hereditary complex resulting from the blending of two incompatible or widely divergent parental qualities, and by crossing varieties one or both of which possess these undesirable qualities. Kato and his collaborators(3) found that the formation of pollen of F_1 plants derived from the same parental type was nearly perfect, but the pollen of hybrids between different types was quite imperfect. The proportion of imperfect pollen grains was 55.7 per cent in the minimum, 75.7 per cent in the maximum, and 66.1 per cent on the average. This abnormality is attributed to the "disharmony of the chromosomes," or to the abnormal development of the pollen following the tetrad formation of the pollen mother cell. By examining the degree of fertility in the hybrid plants and subjecting them to a serodiagnostic test for corroboration, they were able to determine the sexual affinity of the cultivated varieties of rice in Japan and show that morphologically distinct varieties are distantly related in descent. In certain pedigreed varieties, which are also probably of hybrid origin, we have observed a similar defect. The sterile glumes, according to Ramiah(5) contain all the essential organs normally developed, a

fact that has been corroborated by our findings in the Philippines. Field observations indicate that many flowers do not open at all and, on examination, the anthers do not dehisce but simply wither within the glumes. Stigmas are in many cases also found withered.

EVIDENCES OF WHITE STERILITY

Field observations conducted in Trinidad Valley, Mountain Province, and in Rizal Province have shown that the degree of white sterility differs among the varieties there. Their reaction was found as follows: In the Mountain Province, Maletecan, an awned variety, was very susceptible as, to some extent, was Baguan, while Cadiling and Sabol were naturally less susceptible varieties. Sabol is a colored, awned variety, and the possession of pigment may have a certain correlation with resistance in this case. In Rizal Province, Macan Piña, an early variety, was found quite susceptible, and Khao Bai Sri, Apostol, Guinangang, Cruz, and Calibo III were so to a slight degree. Just how the varieties grown in the highlands would behave when planted in the lowlands, or vice versa, with respect to this kind of sterility, remains to be seen. Meanwhile, everything else being equal, it would seem advisable to substitute less or not at all affected varieties for the susceptible ones. In the Mountain Province, Cadiling and Sabol are grown as profitably as the susceptible Maletecan.

In October and November, 1932, field observations conducted at the Alabang Rice Experiment Station on 121 native and exotic varieties in 100-plant plot cultures during their flowering period proved that white sterility was prevalent. Of the total number of varieties observed, 91, or 75.2 per cent, showed this form of sterility in varying degrees, while 30, or 24.8 per cent, were apparently unaffected. Although varieties maturing at different periods were found susceptible, a preponderance of this flower affection was found more frequently and with a greater degree of severity among the early varieties than in the medium- or late-maturing varieties. Among the most seriously affected varieties are Royal from Java, Kathisod from Siam, and the native varieties Minalabon, Caviteña, and Bacao na Barayon. Of the varieties which apparently showed no evidence of sterility were Tongsan of Java, and the local varieties Diamante, Casicad, Bagsit, Carnero, Pulao, Ubanan, Baladong, Tapusan, Inagamang, Tinalahib, Kaongkoy, Kabonbon, Mulan-ay, Maghusay,

Barangcal, Binulinao, Lantec, Salomonay, Sempulec, and Sinandaang Araw, of which five are from the Mountain Province and the rest from various other parts of the Philippines. In order, however, to show a better appreciation of the extent of damage occasioned by white sterility, actual counts were made from twenty panicles taken at random from the 100-plant plots of the varieties listed in Table 1.

TABLE 1.—*Rice varieties showing the presence of white sterility, to a greater or lesser degree, as observed in the 1932–1933 season at Alabang, from twenty panicles picked at random.*

Variety name	Panicles counted	Average sterility	Approximate ratio of sterile to fertile flowers
		Per cent	
Sipot	20	14.96	1:13
Minalabon	20	24.40	1:3
Katilang	20	15.55	1:6
Royal	20	15.90	1:12
Magcumpol	20	17.74	1:6
Caviteña	20	21.75	1:6
Bacao na Barayon	20	20.33	1:6
Señora II	20	16.95	1:7
Baranay	20	14.43	1:7
Macan I	20	23.47	1:4

An examination of Table 1 will show the average proportions of the sterile and fertile flowers per panicle to be approximately from 1:3 to 1:13, depending on the variety, while the average percentage of sterility against the total number of grains formed was, from 14.43 to 24.40.

In Coimbatore, India,(5) white sterility was noted to be particularly bad on wild or semi-wild rices, and also obviously manifest on poor varieties. Pure lines were also affected to a varying extent. Long-awned varieties were, with two exceptions, found to be more easily affected. Weather conditions seem to have a direct influence on the occurrence of white sterility among early varieties, such as Macan Piña, Guinangang Str. 1 and Apostol, for instance, as has been observed in the Alabang Rice Experiment Station, confirming the findings of Ramiah,(5) in Coimbatore, who reported that sterility was quite prevalent among short-maturing varieties.

EVIDENCES OF CROSS STERILITY

Cross sterility was first observed at the Alabang Rice Experiment Station in July, 1928, in three natural hybrid plants in the strain test of Gopher, a variety of American origin (Plate 7, *d*). Except for the colored apiculus and large proportion of

empty grains which were more or less uniformly scattered among well-developed grains in the panicles, these natural hybrids were very similar to the normal Gopher type. They produced a total of 3,124 spikelets, of which 1,501 were normal and 1,623 sterile spikelets showed 1 : 1 ratio, with a deviation of 61.0 ± 18.8.

TABLE 2.—*Sterility in different rice hybrids as shown by the relative proportion of normal and sterile spikelets.*

Crosses	Progenies	Grains			Ratio	Deviation	Probable error
		Normal	Sterile	Total			
Gopher natural hybrids	3	1,501	1,623	3,124	1:1	61.00	±18.80
Baladong x Apostol	5	2,680	2,742	5,422	1:1	31.00	±24.82
Storm Proof x Apostol	3	745	2,018	2,763	1:3	54.25	±22.75

Similar sterility was found in two of the seven crosses made at the station(9) in 1928. From five F_1 plants of Baladong x Apostol cross (Plate 6, middle fig.) there were produced 2,680 normal and 2,742 sterile spikelets, thus deviating only by 31.00 ± 24.82 from the normal 1 : 1 ratio. The Storm Proof x Apostol cross produced three F_2 progenies, consisting of 745 normals and 2,018 sterile spikelets, or approximately a 1 : 3 ratio, the deviation being 54.25 ± 22.75.

An examination of the reproductive organs was made. It was found very difficult to differentiate one kind of ovary from the other in the early stage, even under the microscope. Normal pollen grains could be distinguished easily from the aborted ones, however.

Materials were obtained from two F_1 plants of Baladong x Apostol cross and from one F_1 plant of Storm Proof x Apostol. Ten mounts were made of each plant for the counting of the pollen grains. The results are given in Table 3.

TABLE 3.—*Sterility in different rice hybrids as shown by the relative proportions of functional and nonfunctional pollen grains*

Crosses	Counts	Average number of pollen grains[1]			Ratio	Deviation	Probable error
		Norm. or functional[a]	Nonfunctional[b] and[c]	Total			
Baladong x Apostol (733–1)	10	73.6	94.7	168.3	1:1	10.55	±4.60
Baladong x Apostol (733–2)	10	132.1	144.5	276.6	1:1	6.20	±5.60
Storm Proof x Apostol	10	19.3	105.6	124.9	1:3	11.93	±5.59

[1] ([a]) Large normal or functional pollen grains.
([b]) Small, nonfunctional pollen grains.
([c]) Shriveled or aborted pollen grains.

With the Baladong ♀ x Apostol ♂ cross in two cases the proportion of normal to aborted pollen grains was 1 : 1, and the deviation insignificant. On the other hand, the Storm Proof ♀ x Apostol ♂ cross showed 1 : 3 ratio with deviation of only 11.93 ± 5.59. In the latter cross three types of pollen grains were found: (*a*) large, normal or functional pollen grains; (*b*) small, nonfunctional pollen grains; and (*c*) shriveled, nonfunctional pollen grains. These pollen types fit well 1 : 2 : 1 ratio.

To determine the proportion of semisterile to normal or fertile plants in the F_2 generations, some F_2 seeds were grown from the natural hybrids and artificial crosses, and the results obtained

TABLE 4.—*Segregations of F_2 plants from different rice crosses, showing the proportion of semisterile and normal plants*

Crosses	Progenies	F_2 plants			Ratio	Deviation	Probable error
		Semisterile	Normal	Total			
Gopher natural hybrids	3	262	18	280	15:1	0.50	±2.73
Baladong x Apostol	4	349	110	459	3:1	4.75	±6.26
Storm Proof x Apostol	3	723	54	777	15:1	5.44	±4.55

therefrom are presented in Table 4. The Gopher natural hybrids produced 262 semisterile F_2 plants and 18 normally fertile plants in the ratio of 15 : 1, the deviation being 0.50 ± 2.73. The Baladong x Apostol hybrids gave 349 semisterile F_2 plants and 110 fertile plants resulting in a ratio of 3 : 1, and a deviation of 4.75 ± 6.26. The Storm Proof x Apostol hybrids produced 723 semisterile and 54 fertile plants in the second generation indicating a 15 : 1 ratio and a deviation of 5.44 ± 4.55.

With the foregoing results it is not possible to give any conclusion as to the number of Mendelian factors determining this type of sterility, for the F_3 and succeeding generations were not carried out due to the transfer of the breeder to another project. Notwithstanding this fact, it may be inferred that semisterility in rice hybrids is hereditary in nature as will be subsequently shown in the observations of Messrs. J. O. Unite and G. M. Reyes in certain types of crosses in the F_3 and F_4 generations.

SUMMARY AND CONCLUSIONS

1. The sterility of rice herein reported is of two kinds and both are limiting factors of economic importance in rice production, as they affect the yields materially.

2. White sterility is of commoner occurrence in rice fields than in generally supposed and can be distinguished by the presence

in the panicle of undeveloped, empty, white florets occurring usually in groups in the terminal portions, although they may be found also in other parts of the panicle. Heretofore it has claimed little or no attention.

3. The loss from white sterility has been found to vary from 14.4 to 24.4 per cent in the varieties showing more or less severe affection in the lowlands (Alabang, Rizal), and it may be as high as 25 per cent, as was observed in the highlands (Trinidad, Mountain Province).

4. A preponderance of damage has been observed among the early- over that among the medium- and late-maturing varieties. In the light of these observations, it would seem expedient to plant the early varieties in irrigated districts a little later than usual so that they may not be affected by unfavorable local weather conditions in the vulnerable blooming period, to prevent much damage.

5. Several causes have been attributed to this form of sterility. While the writers are inclined to believe it is an inherent varietal character, it may be induced by adverse weather conditions affecting the vigor and fertilization of the rice plant.

6. There is, too, ample evidence that white sterility results from the formation of defective or degenerate reproductive organs in the panicle containing normal flowers.

7. Cross sterility, on the other hand, does not become clearly manifest until the panicles have reached a certain stage of maturity, and is characterized by the formation of empty, straw-colored flower glumes distributed among the normally developed grains in the panicle. The flowers apparently contain complete sex organs.

8. It is believed to be a hereditary character resulting through natural or artificial crossing of varieties possessing wide morphological characters or distantly related in inheritance; and it may arise from crosses exhibiting sterility in one or both parents.

9. Decreases in yield resulting from the occurrence of cross sterility have been estimated in two hybrid types at from 8.8 to 31.5 per cent and from 20.3 to 60.3 per cent. A tendency was noted for sterility to increase in ratio in the succeeding generations.

10. Experiments and observations on the resistance and susceptibility of rice varieties in different localities need to be made,

with a view to finding any possible relation between altitude or climatic factors and the incidence of sterility.

11. Meanwhile, with our present knowledge of the subject, it would seem advisable, if other conditions warrant it, to substitute less susceptible or unaffected varieties for the ones showing considerable sterility.

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ILLUSTRATIONS

Plate I

Rice panicles of lowland varieties (left to right) Caviteña, Minalabon, Baranay and Bacao na Barayon, showing the occurrence of white sterility at the terminal and basal portions. Photographed from dried specimens. About × 6.

Plate II

Dried panicles of lowland rice varieties (left to right) Macan I, Bacao na Barayon, Royal and Cabatiti exhibiting a more or less distributed or middle occurrence of white sterility. About × 6.

Plate III

Fig. 1. A young rice inflorescence emerging from the boot, obtained from Trinidad, Benguet, Mountain Province, showing early stages in the formation of partial sterility by the appearance of abnormally small, unfilled, white, chartaceous grains. Photographed from fresh specimens. About natural size.

2. Two dried panicles of Maletecan variety from the same locality, showing sterility at the terminal part and at the middle lateral branches. Note the shrunken sterile florets. Reduced in size.

Plate IV

Fig. 1. Portions of two panicles obtained from Mountain Province. The panicle to the left shows sterility observed within the enclosing boot. Note the sterility in the panicle at the right which occurs close to the base. About natural size.

2. Portions of two heads of Maletecan variety showing filling fertile grains and barren grains. Many of the latter have already dropped off. Slightly enlarged.

Plate V

A cross between Elon-elon ♀ x Inadhica ♂ rice varieties, showing the occurrence of sterility in the second generation hybrids indicated by the two panicles in the center and its presence in the male parent variety. Approximately × 6.3.

Plate VI

A cross between Baladong ♀ (left) x Apostol ♂ (right), showing the occurrence of sterility in the second generation indicated by the panicle in the middle. About × 0.5.

Plate VII

Showing a hybrid (*b*) from artificial cross Storm Proof ♀ (*a*) and Apostol ♂ (*c*). Natural hybrid (*d*) from Gopher (*e*) and an unknown variety. About × 0.5.

TEXT FIGURES

Fig. 1. *a*, Portion of a rice spike of Guinangang Str. 1, obtained from a panicle still within the barrel, to show the comparative sizes of normal and sterile flowers, approximately × 3.9. *b*, Reproductive organs obtained from the third flower shown in *a*, possessing all the essential organs but having somewhat less feathery or poorly developed stigmas and the filaments of the abortive stamens not fully extended, about × 6.4.

2. Imperfect pollen grains obtained from sterile florets of the same variety, drawn with a camera lucida to show morphological structures: *a*, Fresh pollen grains without contents; *b*, shriveled pollen grains assuming various shapes; *c*, a burst pollen grain, × 653; *d*, a normal pollen grain to show the difference, × 653; *e*, a highly magnified sterile pollen grain without contents, showing the germ pore at the periphery, × 1,300; *f*, a front view of the germ pore, × 1,300.

PLATE I

PLATE II

1

2

PLATE III

1

2

PLATE IV

PLATE V

PLATE VI

PLATE VII

EXPERIMENTS IN VIRGINIA CIGARETTE TOBACCO PRODUCTION DURING THE 1932–1933 SEASON

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FOUR PLATES

The present report covers only our experiments with Virginia tobacco. It has been decided to submit the experiments in the production of cigarette tobacco in two reports because there are significant differences in the culture as well as in the development of the Turkish and Virginia types of cigarette tobacco.

The production of Virginia cigarette leaf tobacco in the Philippines, although new, is now an established industry. It was only during the tobacco season just ended that farmers in central Luzon and La Union Province grew it on a commercial scale but the product turned out was, on the whole, so satisfactory; such good prices—mostly 20 pesos per quintal—were paid, that whereas only 11,000 kilos were produced, during the coming 1933–1934 season this quantity will probably be fifty times as great. As a matter of fact most of the prospective crops are contracted for and some manufacturers and leaf-tobacco dealers have formed a corporation to raise the product themselves.

Because of this tremendous interest manifested in the production of Virginia cigarette leaf tobacco, we believe it the proper time to publish our report on the experiments on the production of this product during the 1932–1933 season just ended, conducted at various places, mostly at the Alabang Rice Station, Muntinlupa, Rizal Province, Luzon, because of better facilities there. These experiments were virtually continuations of those conducted during the previous 1931–1932 season as reported in this Journal in its issue for the third quarter, of 1932.(2) This being the fact, the experimental procedures are purposely omitted in this paper. Neither is any literature on the subject reviewed, as such articles were adequately covered in the senior author's report in 1930.(1)

EXPERIMENTS CONDUCTED AT THE ALABANG RICE STATION

The field was the same as that used during the previous season and the weather conditions were practically the same also.

Varieties used.—The standard varieties Orinoco, Adcock, North Carolina Bright Yellow, Big Warne, and Conqueror were used for the variety tests. The varieties White Stem Orinoco, Goldleaf, Longleaf Gooch, and Warne were propagated for further standardization, while the native Vizcaya was also propagated for further observation in the possibility of producing the Virginia type of cigarette tobacco out of native stock.

Cultural operations.—The seed was sown October 5, and the plants set out in the field December 12, 1932. The field was prepared by plowing and harrowing the land twice with a tractor. A native plow drawn by a carabao was used in making the furrows. As usual the planting distance was 70 centimeters between the plants and 80 centimeters between the rows. The field was cultivated after planting with the native plow at intervals of two weeks for about two months, when the plants were about to show signs of flowering.

Control of pests and diseases.—The only serious pest during the season was the common red ant, which caused the first sowings of seeds almost to fail by carrying the seeds away. Subsequent harm by the pest, however, was prevented by the use of bait made of three parts corn meal and one part of sugar with just enough water to form a mash. This bait was merely dropped around the tobacco beds.

Regular dusting of the plants with calcium arsenate mixed with sixteen parts sterilized road dust and observance of simple sanitation in the handling of the plants throughout their growing period, helped much in minimizing the attacks by the usual tobacco worms and diseases.

Variety tests.—Because of the sloping topography of the field, a row of 100 plants was taken for a plot and replicated 10 times. The yields were taken separately from each row, then computed on a hectare basis. The variety North Carolina Bright Yellow was used as check. In determining the significance of the yield differences, the mean, the probable error of the mean, and the probable error of the difference were computed in all cases. (See results in Table 1.)

The percentage weight of cured leaves on fresh green leaves for each variety was also determined. The leaves were harvested one by one as they matured and their weights were taken

immediately after harvesting. The weights were again taken after curing, the weighing being always done at about 3 o'clock in the afternoon. The ratios of the cured leaves and the green leaves, as expressed in percentages, the mean, the probable error of the mean, and the probable error of the difference were computed. (See results in Table 2.)

Harvesting experiments.—The relation of the color of the leaves in the fields and the color of cured leaves was again studied in order to check the results of last year. The varieties studied were North Carolina Bright Yellow, Adcock, Orinoco, and the native Vizcaya. After the leaves were harvested they were classified into three groups according to color; namely, (*a*) dark green, (*b*) light green, and (*c*) ranging from light yellow to bright yellow. All the leaves used in this study were cured in the sun. (See results in Table 3.)

Curing experiments.—The same methods as those used in the previous season were adopted; namely, the leaves were cured (*a*) in the sun, (*b*) in a nipa shed, (*c*) in a galvanized-iron shed, and (*d*) in a nipa shed and then in the sun. The number of days it took the leaves to cure by each method was recorded. Notes on the color of the leaves produced from each method were also taken, each method being given three trials. (See results in Table 4.)

In order to find some means whereby the cost of producing flue-cured Virginia tobacco can be reduced, the flue-curing barn constructed at Singalong was equipped with galvanized-iron pipes instead of cast-iron as the ones used in Isabela and reported on in our previous paper.(2) It was during the early part of May, 1933, that some leaves produced in Alabang were cured in this barn.

Flowering observations.—The time when each variety produced flowers was closely observed. Eleven varieties—ten American and one native—were studied. (See results in Table 5.) The observations for last season have been incorporated in this table for comparison.

STATISTICAL STUDIES OF QUANTITATIVE CHARACTERS

In order to determine further the reliability of the variety tests conducted at Alabang, statistical studies of the more important quantitative characters of the standard varieties were made; namely, (*a*) number of standard leaves, (*b*) total height of plants, (*c*) length of leaves, and (*d*) width of leaves.

For the variety tests conducted at the Maligaya Rice Station, Muñoz, Nueva Ecija, only the variety Adcock was statistically studied because it is the only variety thus far that has given a satisfactory performance there.

At Alabang the number of standard leaves per plant for each variety was counted. Twenty-five individuals picked at ramdom were used for each variety, except for the Big Warne, for which there were only fifteen. The counting of leaves was made when the plants were in full bloom. (See results in Table 6.)

In the study of height of plants the same individuals shown in Table 6 were used. In taking the height the measurement was made from the ground to the tip of the flower head. (See results in Table 7.)

The leaf length and width are based on one middle standard leaf of the same plants. (See results in Tables 8 and 9.)

At Maligaya, the same procedure employed at Alabang was used in the study of the quantitative characters made (See results in Table 10).

SPECIAL CASES IN REGIONS UNDER THE FIRST TYPE OF PHILIPPINE CLIMATE

In our previous report we emphasized the fact that the regions in the Philippines most suitable for the culture of cigarette tobacco are those falling under the First Type of climate (according to the classification of the Weather Bureau), that is characterized by two pronounced seasons, dry in winter and spring and wet in summer and autumn. We also mentioned that, besides being of this climatic type, the land must be well drained, all investigations having been performed in open lands less than 50 meters in elevation above sea level.

During the 1932–1933 season, however, we had occasion to note that our First Type of climate is affected by high altitude and mountainous surroundings. It happened during the season that some farmers raised their crops at an elevation of over 1,000 feet in Batangas and one farmer in a small valley surrounded by mountains in La Union. As a result new problems confronted us. In the former, the leaves could not be left in the open in the evening because of invariable heavy dew at night, while in the latter, although there was no dew at night, the leaves simply refused to cure yellow.

DISCUSSION OF RESULTS

Yields per hectare.—Referring to Table 1 it will be noted that the two varieties which gave the highest average yields per hectare were Orinoco, 43.82 ± 2.09 quintals, and North Carolina Bright Yellow, 41.56 ± 1.89. The other varieties, with their corresponding yields were as follows: Adcock, 33.8 ± 1.24; Big Warne, 30.30 ± 1.84; and Conqueror, 27.69 ± 0.98 quintals. By referring to the same table it is evident that North Carolina Bright Yellow is superior to Adcock, Big Warne, and Conqueror, because the mean difference against Adcock is more than three times the probable error of the difference, almost ten times that of Big Warne and more than six times that of Conqueror. On the other hand, Orinoco is better than North Carolina Bright Yellow. The difference in yield, however, between the two varieties is insignificant, because the probable error of the difference is even greater than the mean difference.

The yields obtained this season for almost all the varieties studied are generally larger than those of last season except that of the Adcock, which is about 7 quintals less. Take the North Carolina Bright Yellow, for instance, the yield of this variety last season was only 20 quintals per hectare, while this year it is twice as much. The yield of Conqueror and Big Warne increased also to some extent. The main reason for the increase in yield this year is that the field was plowed deeper and with a tractor. It is also possible that because the varieties are all of foreign origin, their performance improves as they become better acclimatized to Philippine conditions.

Relative weight of green and cured leaves.—It will be observed in Table 2 that the varieties studied vary in percentages of cured weight of leaves. North Carolina Bright Yellow and Adcock do not differ significantly in this character, the mean difference being only about twice the probable error of the difference. On the other hand, the former is superior to both Conqueror and Orinoco, having mean differences of approximately nine and ten times the probable error of the difference, respectively. Big Warne, however, is superior to North Carolina Bright Yellow in this respect, the mean difference in favor of Big Warne being more than four times the probable error of the difference.

Harvesting experiments.—As shown in Table 3 the color of the leaves at the time of harvesting has some bearing on the color

of the cured leaves. In the varieties studied the dark green leaves turned either light brown or dark brown or remained green. The light green leaves, on the other hand, turned bright yellow in the case of North Carolina Bright Yellow, light yellow in Orinoco, and from light brown to light yellow in Adcock and Vizcaya. The leaves with light or bright yellow color when harvested turned light brown or light yellow in the case of North Carolina Bright Yellow and light brown or dark brown in the other varieties. Cutting down the whole stalk of the plants to the base in harvesting gave unsatisfactory results. Only those leaves close to the base of the stalks turned yellow and all the top leaves turned either light brown or dark brown. It is evident from this that the green color of the leaves is the optimum criterion in harvesting.

Curing experiments.—Table 4 gives the four methods of curing tried and shows that each method had practically the same effect on the color of the leaves. If there were differences at all they were too insignificant to be worth consideration. In other words any one of them can be used to give satisfactory results in places having conditions similar to those in Alabang. Complete sun-curing, however, has the advantage over the other methods because of the time gained. In duration of time, the methods may be named in their order of shortness as follows: First, in the sun; second, in a nipa shed then in the sun; third, in a galvanized-iron shed; and fourth, in a nipa shed.

In Alabang, according to our observations from the middle of February to the middle of May, complete sun-curing can be used to advantage, since during this period there is practically no rain or dew which might affect the process while the leaves are in the open without covers.

By subjecting the leaves in the flue-curing barn to the same graduated temperature up to a maximum of 66° C. as described in our previous report,(2) the curing turned out successful.

Some additional valuable points were gained in this test in connection with the flue-curing of Virginia tobacco. The cost of production is reduced considerably by the use of galvanized-iron pipes, this material being very much cheaper than cast iron. Galvanized iron being also easier to heat, much saving is effected in the consumption of fuel.

Although flue-curing of Virginia tobacco is indispensable in regions with short dry seasons like Cagayan Valley, yet it pays to erect a flue-curing barn even in regions where sun-curing is

possible because of a long dry season. In these regions, the flue-curing barn will insure a bigger crop and a full harvest by rendering possible an early as well as a late crop. It will likewise insure the proper curing of the regular crop in case of an early or delayed rainy season. Furthermore, since crop diversification should be practiced, the barn will be handy for the proper curing or dehydration of other profitable farm products like peanuts, onions, ginger, etc., the moisture content of which must be regulated for effective preservation.

Observation on the period of flowering.—A knowledge of the period of flowering of any crop is of vital importance to plant breeders. In order to cross two varieties, their blooming periods must coincide. Correct information on the period of maturity of the different varieties must be in hand because in some localities early maturing varieties are in demand. In Table 5 it will be seen that for two successive years, at least some varieties had more or less a fixed blooming period. The time of flowering this year of the foreign varieties under study ranges from 95 to 149 days from the time of sowing the seed.

The knowledge is also a valuable basis for correlating harvesting and maturity periods.

Interpretation of statistical data.—The following are the analyses and interpretation of statistical data obtained at Alabang.

(*a*) The number of standard leaves is an important character of the tobacco plant. Other factors being equal, a plant with a greater number of leaves will have a larger yield than a plant with less. In the selection of strains, especially for breeding purposes, this character must always be taken into consideration.

Referring to Table 6 it will be readily seen that the varieties studied vary in the average number of leaves per plant. The varieties, with their corresponding average number of leaves, may be named in their order as follows: Orinoco, 25.36 ± 0.49; Adcock, 28.36 ± 0.48; North Carolina Bright Yellow, 19.10 ± 0.36; Big Warne, 1706 ± 0.24 and Conqueror, 15.12 ± 0.29. On the basis of the coefficients of variability it is evident that the variety Conqueror and to a certain extent Adcock need further inbreeding for the character of number of leaves.

(*b*) Table 7 shows that some varieties are taller than others. Big Warne, for instance, is approximately 20 centimeters taller than Conqueror with mean heights of 132.33 ± 2.17 and 112.00 ± 2.98 centimeters, respectively. On the other hand, Adcock and North Carolina Bright Yellow are nearly as tall as Big

Warne. Conqueror with a coefficient of variability of 19.61 ± 1.01 per cent and a standard deviation of 22.08 ± 2.11 is the only variety needing further inbreeding. Using both the standard deviation and coefficient of variability as bases of comparison, the other varieties may be enumerated in their order of variability as follows: North Carolina Bright Yellow, Orinoco, Big Warne, and Adcock. Adcock is the best fixed in this character, since it has only a 7.6 per cent ± 0.37 coefficient of variability.

(*c*) Referring to Table 8 it will be seen that the varieties studied, with their corresponding mean lengths of leaves come in the following order: Big Warne, 53.46 ± 1.15; North Carolina Bright Yellow, 48.16 ± 0.74; Conqueror 46.32 ± 1.13; Adcock, 41.76 ± 0.85; and Orinoco, 41.36 ± 1.24 centimeters. The coefficient of variability shows that Orinoco with 22.17 ± 2.32 per cent, and Conqueror, 18.07 ± 0.92, are the most variable while North Carolina Bright Yellow with 11.39 ± 0.55 per cent is the least variable.

(*d*) In Table 9 it is interesting to note that Orinoco and Conqueror are as variable in width of leaves as in length of leaves, their coefficients of variability being 25.86 ± 1.40 and 23.28 ± 1.23 per cent, respectively, while Big Warne with 12.03 ± 0.76 per cent is the least variable. North Carolina Bright Yellow has the broadest leaves with a mean of 26.44 ± 0.55 centimeters and Orinoco has the narrowest, 11.52 ± 0.40 centimeters.

The behavior of the variety Adcock at Maligaya, as may be observed in Table 10, indicates that its 16.94 ± 0.60 coefficients of variability for number of leaves and 24.95 ± 0.89 for width of leaves, require further selection for these characters.

Special cases in regions under the first type of Philippine climate.—In regions of about 1,000 feet elevation but not surrounded by mountains, the yellow curing of the leaves was attained by taking the trouble to bring the poles or sticks into the shed at sunset until they became too brittle for handling, when they were placed permanently in a galvanized-iron shed until they were thoroughly cured.

In the case of the lowlands surrounded by mountains, the problem is still unsolved. It is unfortunate that when this trouble was discovered the season was about to end and there was no time to try other methods of curing.

Identification of the standard Philippine grown Virginia varieties.—The five Virginia varieties used in the variety test al-

ready discussed are considered standard under Philippine conditions, inasmuch as out of the numerous varieties introduced into the country for the purpose of developing varieties to supply a local aromatic cigarette leaf tobacco product, these varieties not only have thrived locally but their yields, curing qualities, and aroma are very satisfactory.

As these varieties are now being grown all over central Luzon and the Ilocano provinces, it is necessary that a means for their identification be prepared. And for this purpose there is nothing better than the following simple analytical key:

a. Plants short, less than 125 cm..... B.
b. Leaves lanceolate, less than 30 per cent breadth index..... Orinoco.
bb. Leaves, broadly ovate, more than 50 per cent breadth index, few. Conqueror.

aa. Plant medium more than 125 cm..... B.
b. Leaves large, more than 50 cm., ovate..... Big Warne.
bb. Leaves medium, less than 50 cm..... C.
c. Leaves ovate-elliptical ..... Adcock.
cc. Leaves broadly ovate, more than 50 per cent breadth index. North Carolina Bright Yellow.

SUMMARY AND CONCLUSIONS

1. Most of the varieties under study have had larger yields during this season than during the previous one. The increase in yields may have been due either to the more intensive cultivation given to the plants this season or, since it is only the second year of the introduction of most of these varieties, possibly they are still in the process of acclimatization.

2. Orinoco and North Carolina Bright Yellow produced the highest yield of cured leaves per hectare or more than 40 quintals each.

3. The least variable variety, with respect to height of plants, is Adcock; number and width of leaves, Big Warne; and length of leaves, North Carolina Bright Yellow. Big Warne seems to be the most uniform variety with reference to these characters.

4. The proper time to harvest the leaves is when they assume a light green color. At this stage the leaves will turn yellow in curing.

5. Under Alabang conditions the different methods of curing produced the same effect on the color of the leaves. Complete sun-curing has the advantage over the other methods because the leaves dry faster.

6. In high altitudes the leaves should not be left in the open at night. When they become too brittle to handle, they should be left in galvanized-iron buildings until thoroughly dried or cured.

7. In flue-curing, the use of galvanized-iron pipes instead of cast-iron is preferable in that it is not only much cheaper but also easier to heat.

8. The time of flowering of the ten different foreign cigarette tobacco varieties and one native variety under study ranges between three and five months.

9. As regards color of leaves (yellowness), North Carolina Bright Yellow is superior.

10. Among the varieties studied, the leaves of Orinoco had the highest moisture content and the leaves of Big Warne had the least. Their average cured weights in percentage on the basis of green weights were 13.82 ± 0.38 and 21.25 ± 0.47.

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Table 1.—*Yield of five cigarette tobacco varieties tested at the Alabang Rice Station during the season 1932–1933*

NORTH CAROLINA BRIGHT YELLOW (CONTROL)

Row	Quintals per hectare	d	d^2	
A–1	45.71	+ 4.15	17.22	
A–2	36.78	— 4.78	22.84	
A–3	38.56	— 3.00	9.00	
A–4	56.45	+14.89	221.71	
A–5	31.78	— 9.78	95.64	M=41.56 ±1.89
A–6	57.49	+15.93	253.76	
A–7	39.64	— 1.92	3.69	
A–8	38.21	— 3.35	11.22	
A–9	34.64	— 6.92	47.88	
A–10	36.42	— 5.14	26.41	
Average	41.56		$\leq d^2$ 709.37	

TABLE 1.—*Yield of five cigarette tobacco varieties tested at the Alabang Rice Station during the season 1932–1933*—Continued

ADCOCK

Row	Quintals per hectare	d	d^2	
B-1	31.78	— 2.10	4.41	
B-2	28.92	— 4.96	24.60	
B-3	42.49	+ 8.61	74.13	
B-4	27.85	— 6.03	36.36	M=33.88±1.24
B-5	36.07	+ 2.19	4.79	
B-6	26.78	— 7.10	50.41	A=41.56±1.89
B-7	28.57	— 5.31	28.19	B—33.88±1.24
B-8	35.71	+ 1.83	1.51	
B-9	41.42	+ 7.54	56.85	7.68±2.28
B-10	39.28	+ 5.40	29.16	
Average	33.88	.....	Σd^2 310.41	

BIG WARNE

C-1	38.78	+ 8.48	71.91	
C-2	21.78	— 8.52	72.59	
C-3	48.21	+17.91	320.76	
C-4	28.57	— 1.73	2.99	M=30.30± 1.84
C-5	23.92	— 6.38	40.70	
C-6	31.78	+ 1.48	2.19	A—41.56 ±1.89
C-7	19.99	—10.31	106.29	C —30.30±1.84
C-8	35.71	+ 5.41	29.26	
C-9	29.28	— 1.02	1.04	11.26±2.64
C-10	24.99	— 5.31	28.19	
Average	30.30	.....	Σd^2 675.92	

CONQUEROR

D-1	30.35	+ 2.66	7.07	
D-2	32.76	+ 5.07	25.70	
D-3	25.35	+ 2.34	5.47	
D-4	28.21	+ 0.52	0.27	M=27.69±0.98
D-5	26.07	— 1.62	2.62	
D-6	33.92	+ 6.23	38.81	A—41.56±1.89
D-7	28.92	+ 1.23	1.51	D—27.69±0.98
D-8	30.35	+ 2.66	7.07	
D-9	20.71	— 6.98	48.72	13.87±2.13
D-10	20.35	— 7.34	53.87	
Average	27.69	.....	Σ^2 191.11	

ORINOCO

E-1	66.22	+12.40	153.76	
E-2	55.35	+11.82	139.71	
E-3	35.71	— 8.17	66.74	
E-4	33.92	— 9.90	98.01	M=43.82±2.09
E-5	31.42	—12.40	153.76	
E-6	34.64	— 9.18	84.27	E—43.82±2.09
E-7	48.20	+ 4.38	19.18	A—41.56±1.89
E-8	49.64	+ 5.82	33.87	
E-9	48.82	+ 5.00	25.00	2.26±2.82
E-10	34.28	— 9.54	91.01	
Average	43.82	.....	Σd^2 865.31	

Rice Station during the season 1932–1933—Continued

SUMMARY OF TABLE 1

Variety name	Mean	Difference in favor of control
North Carolina Bright Yellow (control)	41.56±1.89	
Adcock	33.88±1.24	7.68±2.28
Big Warne	30.30±1.84	11.26±2.64
Conqueror	27.69±0.98	13.87±2.13
Orinoco	43.82±2.09	+2.26±2.82

TABLE 2.—*Relative weight of cured and green leaves in five cigarette tobacco varieties*

NORTH CAROLINA BRIGHT YELLOW (CONTROL)

Determination number	Cured leaves in green leaves	d	d^2	
	Per cent			
A–1	17.95	—0.92	0.8464	
A–2	19.97	+1.10	1.2100	
A–3	20.79	+1.92	3.6864	
A–4	19.07	+0.20	0.0400	
A–5	20.05	+1.18	1.3924	M=18.87±0.2640
A–6	19.59	+0.72	0.5184	
A–7	18.37	—0.50	0.2500	
A–8	17.42	—1.45	2.1025	
A–9	18.57	—0.30	0.0900	
A–10	16.95	—1.92	3.6864	
Average	18.87		Σd^2 13.82	

ADCOCK

B–1	16.52	—1.42	2.0164	
B–2	15.61	—2.33	5.4289	
B–3	16.03	—1.91	3.6481	M=17.94±0.3649
B–4	17.41	—0.53	0.2809	
B–5	17.72	—0.22	0.0484	A—18.87±0.2640
B–6	17.75	—0.19	0.0361	B—17.94±0.3649
B–7	21.15	+3.21	10.3041	
B–8	18.65	+0.71	0.5041	0.93±0.4503
B–9	19.46	+1.52	2.3104	
B–10	19.17	+1.23	1.5129	
Average	17.94		Σd^2 26.09	

BIG WARNE

C–1	21.03	—0.22	0.0484	
C–2	21.53	+0.28	0.0784	
C–3	16.74	—4.61	21.2521	M=21.25±0.4732
C–4	21.50	+0.25	0.0625	
C–5	23.54	+2.29	5.2441	C—21.25±0.4732
C–6	22.86	+1.61	2.5921	A—18.87±0.2640
C–7	19.12	—2.13	4.5369	
C–8	22.16	+0.91	0.8281	2.38±0.5417
C–9	20.00	—1.25	1.5625	
C–10	24.05	+2.85	8.1225	
Average	21.25		Σd^2 44.32	

tobacco varieties—Continued

CONQUEROR

Determination number	Cured leaves in green leaves	d	d^2	
	Per cent			
D–1	16.76	+0.96	0.9216	
D–2	14.79	—1.01	1.0201	
D–3	15.10	—0.70	.4900	M=15.80±0.2008
D–4	15.46	—0.34	.1156	
D–5	15.70	—0.10	.0100	A—18.87±0.2640
D–6	14.53	—1.27	1.6129	D—15.80±0.2008
D–7	15.75	—0.05	.0025	
D–8	15.67	—0.15	.0225	3.07±0.3316
D–9	16.91	+1.11	1.2321	
D–10	17.40	+1.60	2.5600	
Average	15.80		$\leq d^2$ 7.99	

ORINOCO

E–1	17.91	+4.09	16.7281	
E–2	13.00	—0.82	.6724	
E–3	11.47	—2.35	5.5225	M=13.82±0.3842
E–4	14.33	+0.51	.2601	
E–5	15.40	+1.58	.3364	A—18.87±0.2640
E–6	14.59	+0.77	.5929	E—13.82±0.3842
E–7	13.37	—0.45	.2025	
E–8	13.62	—0.20	.0400	5.05±0.4661
E–9	12.50	—1.32	1.7424	
E–10	12.05	—1.77	3.1329	
Average	13.82		$\leq d^2$ 29.23	

SUMMARY OF TABLE 2

Variety name	Mean	Difference in favor of control
North Carolina Bright Yellow (control)	18.87±0.2640	
Adcock	17.94±0.3649	0.93±0.4503
Big Warne	21.25±0.4732	+2.38±0.5417
Conqueror	15.80±0.2008	3.07±0.3316
Orinoco	13.82±0.3842	5.05±0.4661

TABLE 3.—*The relation of the color of the leaves in the field and the color of the cured leaves* [a]

Variety name	Color of leaves when harvested			Cutting the entire stock
	1. Dark green	2. Light green	3. Light yellow to bright yellow	
	Color of cured leaves			
North Carolina Bright Yellow.	Light brown to dark brown.	Bright yellow. . .	Light brown to light yellow.	In nearly all cases only the sand leaves and a lower standard leaves turned either light yellow or bright yellow. All the rest turned either light brown or dark brown.
Adcock.	Dark green to dark brown.	Light brown to light yellow.	Light brown to dark brown.	
Philippine Vizcaya.	Dark green to dark brown.	Light brown to light yellow.	Light brown to dark brown.	
Orinoco.	Dark green to dark brown.	Light yellow. . . .	Light brown to dull yellow.	
Samsoun Bafra. .	Light brown to dark green.	Bright yellow. . .	Light brown to light yellow.	

[a] The results in this table were based on at least five trials.

TABLE 4.—*Effect of the different methods of curing on the color of the leaves and the number of days it takes to cure the leaves* [a]

Variety name	Method of curing												Remarks
	1. In the sun		2. Under nipa shed			3. Under galvanized iron roof			4. Under nipa shed and then in the sun				
	Average number of days to cure the leaves	Color of leaves in the order of yellowness	Average number of days to cure the leaves	Difference in favor of method No. 1	Color of leaves in the order of yellowness	Average number of days to cure the leaves	Difference in favor of method No. 1	Color of leaves in the order of yellowness	Average number of days to cure the leaves	Difference in favor of method No. 1	Color of leaves in the order of yellowness		
North Carolina Bright Yellow	21.0	I	26.3	5.3	I	23.3	2.3	I	21.3	0.3	I		In general the color of the leaves for each variety in the four methods of curing were practically the same.
Adcock	15.6	II	23.3	7.7	II	23.0	7.4	II	17.6	2.0	II		
Orinoco	19.3	III	28.3	9.0	III	25.0	5.7	III	26.6	7.3	III		
Vizcaya	17.6	IV	24.6	7.0	IV	24.6	7.0	IV	20.0	2.4	IV		

[a] The figures in this table are averages of three trials.

TABLE 5.—*Showing the number of days it takes the different cigarette tobacco varieties to produce flowers under Alabang conditions*

Variety name	1931–1932			1932–1933		
	Date of sowing	Flowers appeared	Days from sowing to flowering	Date of sowing	Flowers appeared	Days from sowing to flowering
North Carolina Bright Yellow	10–14–31	1–28–32	106	9– 7–32	12–15–32	99
White Stem Orinoco	10–14–31	1–20–32	98	9– 7–32	12–18–32	102
Goldleaf	10–14–31	1–26–32	104	9– 7–32	12–15–32	99
Longleaf Gooch	10–14–31	1–25–32	103	9– 7–32	12–26–32	110
Conqueror	10–14–31	2–13–32	122	9– 7–32	12–16–32	100
White Burley				9– 7–32	1– 2–33	117
Orinoco				9– 7–32	2– 3–33	149
Philippine Vizcaya				9– 7–32	2–21–33	167
Adcock	10–14–31	2–13–32	122	9–13–32	12–26–32	104
Warne	10–14–31	1– 1–32	79	9–13–32	12–17–32	95
Big Warne	10–14–31	1–27–32	105	9–13–32	1–10–33	119

TABLE 6.—*Frequency distribution of standard leaves per plant in five cigarette tobacco varieties raised in Alabang*

Variety name	Class centers for number of standard leaves													
	10	12	14	16	18	20	22	24	26	28	30	32	34	36	Total
North Carolina Bright Yellow			1	3	10	6	2	3							25
Adcock				2	2	1	6	6	3	4	1				25
Big Warne			1	6	7	1									15
Conqueror	3	4	4	5	8	1									25
Orinoco				1	0	0	8	4	4	4	1	2	0	1	25

Variety name	Mean	Standard deviation	Coefficient of variability
North Carolina Bright Yellow	19.10±0.35	2.57±0.24	13.45±0.77
Adcock	23.36±0.48	3.58±0.34	15.32±0.76
Big Warne	17.06±0.24	1.39±0.17	8.14±0.51
Conqueror	15.12±0.39	2.91±0.28	19.24±0.97
Orinoco	25.36±0.49	3.65±0.35	14.39±0.71

TABLE 7.—*Frequency distribution of height of plants in five cigarette tobacco varieties raised at Alabang*

Variety name	Class centers for height of plants in cm								
	85	90	95	100	105	110	115	120	125
North Carolina Bright Yellow				1	3	1	3	0	3
Adcock							3	3	3
Big Warne								4	2
Conqueror	3	2	3	3	1	1	2	1	2
Orinoco			2	3	2	5	5	4	0

Variety name	Class centers for height of plants in cm								
	130	135	140	145	150	155	160	165	Total
North Carolina Bright Yellow	5	3	1	2	1	1	1		25
Adcock	9	1	3	2	0	1			25
Big Warne	4	1	1	1	1	0	0	1	15
Conqueror	0	1	2	4					25
Orinoco	2	0	0	1	1				25

Variety name	Mean cm	Standard deviation	Coefficient of variability
North Carolina Bright Yellow	127.80±2.15	15.92±1.52	12.48±0.61
Adcock	130.00±1.33	9.88±0.94	7.60±0.37
Big Warne	132.33±2.17	12.49±1.54	9.43±0.59
Conqueror	112.60±2.98	22.08±2.11	19.61±1.01
Orinoco	114.40±1.80	13.37±1.28	11.44±0.56

TABLE 8.—*Frequency distribution of length of leaves in five cigarette tobacco varieties raised at Alabang*

Variety name	Class centers for length of leaves in cm									
	30	32	34	36	38	40	42	44	46	48
North Carolina Bright Yellow					1	2	4	2	0	3
Adcock		2	1	4	4	1	3	2	3	1
Big Warne						1	0	0	1	2
Conqueror				5	1	2	3	1	2	1
Orinoco	3	5	1	0	2	1	1	4	1	3

Variety name	Class centers for length of leaves in cm								Total
	50	52	54	56	58	60	62	64	
North Carolina Bright Yellow	2	7	2	1	1				25
Adcock	0	3	1						25
Big Warne	2	1	3	0	2	0	1	2	15
Conqueror	3	1	3	0	1	0	0	2	25
Orinoco	1	0	1	0	1				25

Variety name	Mean	Standard deviation	Coefficient of variability
North Carolina Bright Yellow	48.16±0.74	5.49±0.52	11.39±0.55
Adcock	41.76±0.86	6.74±0.60	15.23±0.76
Big Warne	53.46±1.15	6.63±0.82	12.40±0.80
Conqueror	46.32±1.13	8.37±0.79	18.07±0.92
Orinoco	41.36±1.24	9.17±0.87	22.17±2.32

TABLE 9.—*Frequency distribution of width of leaves in five cigarette tobacco varieties raised at Alabang*

Variety name	Class centers for width of leaves in cm								
	8	10	12	14	16	18	20	22	24
North Carolina Bright Yellow						1	1	3	5
Adcock					5	3	6	4	5
Big Warne							1	2	4
Conqueror				2	0	2	5	4	1
Orinoco	6	5	8	4	0	1	1		

Variety name	Class centers for width of leaves in cm							Total
	26	28	30	32	34	36	38	
North Carolina Bright Yellow	3	5	3	3	1			25
Adcock	1	1						25
Big Warne	3	3	1	1				15
Conqueror	2	4	4	0	0	0	1	25
Orinoco								

Variety name	Mean	Standard deviation	Coefficient of variability
North Carolina Bright Yellow	26.44±0.55	4.07±0.37	15.39±0.77
Adcock	20.64±0.45	3.31±0.32	16.04±0.80
Big Warne	25.60±0.54	3.08±0.38	12.03±0.76
Conqueror	23.92±0.75	5.57±0.53	23.28±1.23
Orinoco	11.52±0.40	2.98±0.28	25.86±1.40

TABLE 10.—*Frequency distribution of number of standard leaves, height of plants, and length and width of leaves of the Adcock variety grown in Maligaya, Nueva Ecija.*

A. NUMBER OF STANDARD LEAVES

Class centers (cm)	16	18	20	22	24	26	28	30	32	34	Total
Frequency distribution	2	2	18	12	5	3	3	2	3	.....	50

Mean	Standard deviation	Coefficient of variability
22.6±0.37	3.88±0.26	16.9±0.60

B. HEIGHT OF PLANTS

Class centers (cm)	120	125	130	135	140	145	150	155	160	Total
Frequency distribution	5	6	3	9	12	6	5	1	3	50

Mean	Standard deviation	Coefficient of variability
137.8±1.01	10.66±0.72	7.74±0.26

C. LENGTH OF LEAVES

Class centers (cm)	30	32	34	36	38	40	42	44	46	48	Total
Frequency distribution	2	2	10	6	3	9	4	11	2	1	50

Mean	Standard deviation	Coefficient of variability
38.92±0.43	4.60±0.31	11.81±0.41

D. WIDTH OF LEAVES

Class centers (cm)	16	18	20	22	24	26	28	Total
Frequency distribution	5	8	13	8	10	4	2	50

Mean	Standard deviation	Coefficient of variability
21.20±0.30	3.17±0.21	24.95±0.89

ILLUSTRATIONS

Plate I

Fig. 1. Various steps in the preparation of the seed beds.
2. Seed beds with cogon cover completed.

Plate II

Fig. 1. Method of poling the leaves preparatory to curing. The arrangement of the leaves in the string is face to face and back to back.
2. Method of curing the leaves in the sun. The nipa cover at the left is used for covering the leaves in case of rain and dew.

Plate III

Fig. 1. The Adcock tobacco variety; a typical plant.
2. The North Carolina Bright Yellow tobacco variety; a typical plant.

Plate IV

Fig. 1. The Big Warne tobacco variety; a typical plant.
2. The Conqueror tobacco variety; a typical plant.

1

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PLATE I

1

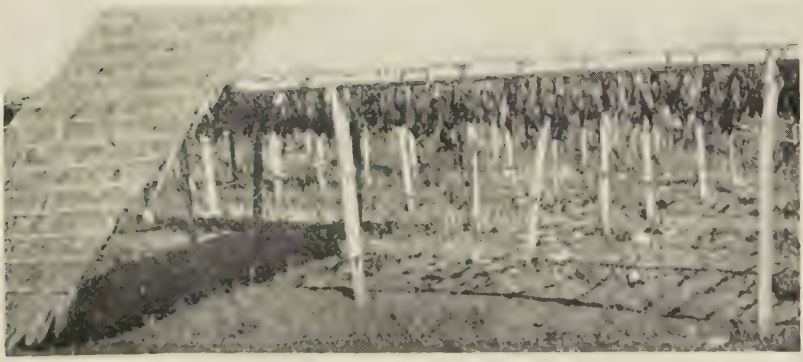

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PLATE II

1

2

PLATE III

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2

PLATE IV

STUDIES ON IRISH POTATOES AT THE BAGUIO SEMI-TEMPERATE FRUIT STATION, MOUNTAIN PROVINCE, LUZON, 1930–1932

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ONE PLATE

This paper is partly a continuation of two separate articles previously published by the writer.[1] It was considered necessary to prepare this report for two reasons: First, the research work started by the writer at the Baguio Semi-temperate Station was discontinued because of his transfer to the Central Office to take charge of vegetable research and therefore the getting of more data to corroborate what has already been obtained may not be possible for some time; and second, to make the data so far obtained available to the public, thus meeting the need for more information on Irish potato culture in the Philippines.

The studies that were undertaken consisted of the following:

I. Potato production as affected by date of planting, 1930–1932.
II. The effect of commercial fertilizers on potato production, 1930–1932.
III. Variety test on Irish potatoes, 1931–1932.
IV. A preliminary study on the storing of the potato tubers for seeds; and on its yielding power, 1931–1932.

The first two experiments were run for a period of two years, and the last two were for a year only. The stand and production of the crops during the 1931–1932 cropping season were, in general, better than those of 1930–1931. This was mainly due to the use of Bordeaux mixture spray to control potato blights, and partly because of a better field knowledge of the culture of the crop.

I. POTATO PRODUCTION AS AFFECTED BY DATE OF PLANTING

As already reported,[2] the object of the study was to determine the best time to plant Irish potatoes in Trinidad Valley, Mountain Province. In the first test, four sets of plantings were

[1] Philip. Journ. Agr. 3 (1932) 39–47 and 49–57. [2] T. c. 39–47.

made, and each set was replicated nine times. In the second test, there were five sets of plantings, and each set was replicated eight times. All the plots were fertilized with guano and a commercial fertilizer (16.5–16.5–21.5) at the rate of 400 kilos of each to a hectare. The plots were also irrigated whenever necessary, which was not the case in the first test.

Table 1 presents a summary of the results of the second test (1931–1932); Table 2 is a summary of the results for the two years.

TABLE 1.—*Showing the average yield of a 25-square meter plot as affected by date of planting 1931–1932*

Date of planting	Yield of tubers per plot		Difference between two plantings on yield of marketable tubers	Significance of difference
	Total	Marketable		
	Kilos	*Kilos*	*Kilos*	
November 2, 1931	10.00±0.46	9.10±0.44	.....	
November 18, 1931	13.20±0.48	11.60±0.45	2.50±0.63	Significant.
December 15, 1931	18.80±1.12	18.20±1.27	6.60±1.35	Do.
January 15, 1932	19.60±1.12	18.90±1.06	0.70±1.65	Insignificant.
January 18, 1932	16.50±0.66	15.70±0.66	—3.20±1.25	Slightly significant.

TABLE 2.—*Showing the effect of date of planting on the yield of marketable tubers per hectare*

Date of planting	Yield of marketable tuber per hectare			
	1930–1931 test[a]		1931–1932 test	
	Kilos	Relative	Kilos	Relative
		Per cent		*Per cent*
November 2	.....	.....	3,640	100
November 15	736	100	4,640	128
December 15	3,000	408	7,280	200
January 15	2,440	345	7,560	205
February 15	1,440	196	6,280	173

[a] This test plot was not fertilized nor was it sprayed with Bordeaux mixture.

It will be seen in Table 1 that the December 15 and January 15 plantings gave the highest average yields both in the total and marketable tubers. In the 1930–1931 test, the December 15 planting gave a slightly greater production,[3] but in the 1931–1932 test, the January 15 planting was slightly better in yield. In both cases, however, the difference was mathematically insignificant. The February 18 planting was the third best, and followed by the November 15 planting. The early planting (November 2) was the poorest. This was due, perhaps, to the greater amount of rainfall that occurred during the life of the plants.

[3] Loc. cit.

The best yields of marketable tubers in the 1931–1932 season were obtained from those planted December 15 and January 15; they gave an average yield of 7,280 and 7,560 kilos, respectively, per hectare. In the light of the two years' results, the best time to plant potatoes in Trinidad Valley and in Baguio, Mountain Province, is about December 15 to January 15.

II. THE EFFECT OF COMMERCIAL FERTILIZERS ON POTATO PRODUCTION

This study was conducted for two years, and the plan of the work was the same as previously reported.[4] The fertilizer (9–12–9) was applied at three rates, and each rate was replicated ten times. The application was made a day previous to planting, and the furrow system was employed. The plants were liberally irrigated and sprayed with Bordeaux mixture. The plots were cultivated and weeded as uniformly as was possible.

In the 1931–1932 test, a representative sample of the marketable tubers from each treatment was weighed to determine the average weight of each tuber. In this way one could get some idea as to whether the increase in yield brought about by the application of fertilizers was due to the increase in the size of the tubers or due to the increase in the number of tubers produced per plant.

Table 3 presents a summary of the 1931–1932 test and Table 4, is a summary of the 1930–1931 and 1931–1932 tests.

TABLE 3.—*Showing the actual yield of 25-square meter plots of Irish potatoes and the size of marketable tubers as affected by the amount of fertilizer (9–12–9) applied.*

Plot No.	Rate of application per hectare							
	Check		200 kilos		450 kilos		700 kilos	
	Total	Marketable	Total	Marketable	Total	Marketable	Total	Marketable
	Kilos	*Kilos*	*Kilos*	*Kilos*	*Kilos*	*Kilos*	*Kilos*	*Kilos*
1	13.2	12.8	18.0	17.5	21.4	20.7	22.4	21.6
2	10.8	10.5	15.4	15.1	19.0	18.6	21.4	20.7
3	12.2	11.9	17.4	16.7	21.2	20.5	21.8	21.3
4	10.2	9.9	13.6	13.2	15.6	15.0	18.4	17.9
5	11.0	10.7	20.4	19.7	18.2	17.6	18.0	17.4
6	10.0	9.7	17.7	17.1	17.0	16.6	20.8	20.0
7	10.8	10.2	14.4	13.7	23.4	22.3	21.4	20.6
8	9.4	9.0	14.8	14.2	17.6	16.9	21.2	20.4
9	10.8	10.4	17.0	16.2	21.4	20.9	23.5	22.7
10	11.7	11.3	14.4	13.8	19.8	19.1	23.3	22.8
Average	11.00	10.60	16.30	15.70	19.50	18.80	21.20	20.50
Probable error	±0.27	±0.22	±0.44	±0.42	±0.49	±0.47	±0.37	±0.36
Average weight of 100 tubers....grams....	64.3±1.62		70.8±1.93		80.9±2.40		87.5±2.77	

[4] T. c. 49–57.

TABLE 4.—*Comparative yields of 25-square meter plots of potatoes as affected by different amouts of a 9–12–9 fertilizer.*

Rate of application per hectare	Average total yield per plot	Increase over check	Significance of difference	Average marketable tubers per plot	Increase over check	Significance of difference
Kilos	*Kilos*	*Kilos*		*Kilos*	*Kilos*	
Check	11.0±0.27			10.6±0.22		
200	16.3±0.44	5.3±0.52	Significant.	15.7±0.42	5.1±0.47	Significant.
450	19.5±0.49	8.5±0.56	do.	18.8±0.47	8.2±0.52	Do.
700	21.2±0.37	10.2±0.46	do.	20.5±0.36	9.9±0.42	Do.

TABLE 5.—*Showing the yield of Irish potatoes as affected by the amount of fertilizer (9–12–9) applied*

Rate of application per hectare	Marketable tubers only					
	1930–1931 test		1931–1932 test		Average	
	Kilos	Relative	Kilos	Relative	Kilos	Relative
Kilos		*Per cent*		*Per cent*		*Per cent*
Check	2,136	100	4,240	100	3,188	100
200	3,120	126	6,280	145	4,700	136
450	4,208	173	7,520	175	5,864	174
700	4,560	187	8,200	190	6,380	189

The effect of fertilizers on growth.—No apparent fertilizer injury was noted, as in the 1930–1931 test, perhaps, due to the liberal supply of irrigation water during the early growing period of the plants. The effect of the fertilizers applied was readily noticeable soon after the shoots began to appear above ground. The plants in the fertilized plots were stout, dark green, and had vigorous growth.

The effect of fertilizers on production.—As seen in Tables 3 and 4, the fertilized plots gave greater average yields than the check plots, and as in the 1930–1931 test,[5] the increases in yields, of both total and marketable tubers, over the check plots were decidedly significant (Table 4).

Comparing the average yields of the plots receiving different amounts of fertilizers, it will be seen in Table 4 that the increase in yield was more or less proportional to the amount of fertilizers applied. The plots fertilized at the rate of 200 kilos per hectare gave an average total yield of 16.3 ± 0.44 kilos, and 15.7 ± 0.42 kilos of marketable tubers. The plots receiving 450 kilos per hectare, on the other hand, gave an average total yield of 19.5 ± 0.49 kilos, and 18.8 ± 0.47 kilos of marketable tubers, giving an increase over the 200-kilo rate per hectare of 3.2 ± 0.65 kilos in average total yield, and 3.1 ± 0.63 kilos in market-

[5] Philip. Journ. Agr. 3 (1932) 49–57.

able tubers. These increases are considered significant. The plots with 700-kilo rate per hectare gave an average total yield of 21.2 ± 0.37 kilos, and 20.5 ± 0.36 kilos of marketable tubers, thus showing an increase of 1.7 ± 0.61 kilos in average total yield, and 1.7 ± 0.59 kilos in marketable tubers over the 450-kilo application per hectare. These increases were only slightly significant. These results, too, corroborate those of the 1930–1931 test.

As seen in Table 5, the average yield in marketable tubers of the check plots in the two-year test was 3,188 kilos per hectare against the 4,700, 5,864, and 6,380 kilos of the plots fertilized at the rate of 200, 450, and 700 kilos per hectare, respectively. In terms of percentage, the corresponding increases over the check plots were 36, 74, and 89 per cent, respectively.

The effect of fertilizer on the size of tubers.—The fertilized plots produced bigger (heavier) tubers than the unfertilized ones (Table 3). There was an apparent tendency for the marketable tubers to be heavier and bigger in the plots which received heavier dressings of fertilizer. This tendency may have been due to the bigger and stouter stems of the plants as a result of vigorous growth brought about by the fertilizer applied.

III. VARIETY TEST

This study had for its object the finding of the best variety for planting in Baguio and in Trinidad Valley, Mountain Province, both in yield and in keeping and eating qualities. At the time this experiment was being carried on, three varieties were more widely grown in the region than others, but due to lack of available seed, only two varieties were included in the test; namely, the Japanese Red and the Japanese White. The Spanish potato, or neutralized potato, in the Mountain Province, that is grown by the natives, was not included.

The study was conducted during the 1931–1932 potato season; the two varieties were planted in 25-square-meter plots and replicated eight times each. As bases of comparison, the following criteria were used: (*a*) number of days to maturity, (*b*) number of shoots per hill, (*c*) number of tubers per hill, (*d*) nature of producing tuber, (*e*) yield per unit area, (*f*) weight of individual marketable tubers, and (*g*) storing and eating quality of tuber. In getting data on the number of shoots per hill, number of tubers per hill, and weight of marketable tubers, 100 determinations each were made at random. Table 6 gives a summary of these studies.

TABLE 6.—*Showing comparative difference in yield, weight of tubers, storing quality, etc., of two potato varieties.*

Character studied	Name of variety		Difference	Significance of difference
	Japanese White	Japanese Red		
	Kilos	*Kilos*	*Kilos*	
Average total yield per 25-square-meter plot.	28.2±1.61	37.7±1.32	6.5±2.08	Slightly significant.
Average marketable tuber per 25-square-meter plot	27.1±1.61	33.4±1.30	6.3±2.07	Do.
Average weight of individual tubers in grams.	82.5±3.00	149.7±5.91	67.2±6.63	Significant.
Average number of shoots per hill.	2.8±0.07	1.1±0.03	1.7±0.07	Do.
Average number of tubers per hill.	6.2±0.20	3.3±0.11	2.9±0.23	Do.
Percentage rotten when stored for four months.	0.5±0.23	14.2±1.33	13.7±1.35	Do.

Of the two varieties tested, the Japanese Red was the later in maturing; it matured twelve days later than the Japanese White, which matured in eighty-nine days after planting. The Japanese White, as its name indicates, has white skinned tubers, round to elliptical in shape with shallow eyes, while the Jananese Red has light red skin, round or spherical tubers with comparatively shallow eyes. The tubers in the case of the Japanese White were formed or clustered together close to the base of the plant while in the case of the Japanese Red, many of the tubers were formed or located several centimeters away from the stem (see fig. 1) ; this behavior is especially true when the soil is friable. This characteristic of the variety must be considered in time of cultivation; the plow or cultivator should not come within the 20-centimeter limit from the base of the plant in the case of the Japanese Red so as not to destroy the developing tubers.

The Japanese White had decidedly more shoots and tubers per hill than the Japanese Red. The number of shoots per hill of the Japanese White was 2.8 ± 0.07 against 1.1 ± 0.03 of the Japanese Red, and 6.2 ± 0.20 tubers per hill of the Japanese White against 3.3 ± 0.11 for the Japanese Red. On the other hand, the Japanese Red had decidedly bigger tubers, the average weight of a marketable tuber being 149.7 ± 5.91 grams against 82.5 ± 3.00 grams for the Japanese White. The fact that the Japanese Red had fewer tubers per hill and that the tubers were not crowded at the base of the plants as in the case of the Japanese White, may account for the bigger tubers of the former. In yield per unit area, the Japanese Red was slightly better. The production of a 25-square-meter plot was 28.2 ± 1.61 kilos in average total yield, and 27.1 ± 1.61 kilos in marketable tubers for the Japanese White, while the corresponding yield in the

case of the Japanese Red were 34.7 ± 1.32 and 33.4 ± 1.30 kilos, respectively. The differences in both cases, however, are considered only slightly significant (see Table 6).

Tests on the storing and eating qualities of the two varieties showed that the Japanese White was far superior to the Japanese Red. When the tubers were stored in crates in an ordinary room for about three months a few weeks after digging of the Japanese White only 0.5 per cent became rotten or partly so, while 14.2 per cent of the Japanese Red decayed. As to eating quality, the Japanese White was also superior; it had a better taste and was firmer in texture. The Japanese Red was rather friable and watery when cooked, especially so the big tubers.

IV. STORING OF BAGUIO-GROWN POTATOES FOR SEED AND ITS VALUE AS SUCH

At the present time, the seed is a big item of expense in connection with the growing of Irish potatoes in the Philippines. To make potato growing a paying industry, the seed should be locally produced. It was because of the desire to solve this particular problem that a preliminary study in the storing of Philippine grown potatoes for seed purposes was started. Part of the harvest of the 1930–1931 crop of the Baguio Semi-Temperate Fruit Station was used as material for the study. Two crates of selected tubers of the Japanese White were used. One crate was buried under one of the houses at the Baguio Semi-temperate Fruit Station to a depth of 1 foot (30 centimeters) from the top of the crate to the surface of the ground. The soil in this place remained comparatively dry until about September when it got wet because of a storm. The other crate was stored in the office. The period of storage lasted for four months—from June to September, 1931. It was decided to determine the storing test in September so as to save some tubers for planting purposes.

At the close of the storing test, the two sets of seed potatoes were examined and the number of germinated tubers counted, and so with those that were rotten. The tubers stored in an ordinary room and those buried under a house had all germinated; they produced long and slender shoots. Those stored in the office became badly shriveled and were very soft, while those buried were still hard and smooth.

Selected seed potatoes from both sets of tubers were planted side by side with fresh seed from Japan of the same variety. Table 7 presents a summary of this study.

TABLE 7.—*Showing the performance of Baguio-grown Japanese White potatoes compared with imported seed of the same variety*

Description of seed used	Germination	Yield per 25-square meter plot		
		Total yield		Significance of difference
		Weight	Difference	
	Per cent	*Kilo*	*Kilo*	
Imported seed from Japan (control)	96.1	14.9±0.64	.....	.....
Baguio-grown (crated and stored in a room)	69.0	3.4±0.36	—11.5±0.73	Significant.
Baguio-grown (crated and buried under a building)	69.1	4.9±0.28	—10.0±0.70	Do.

Description of seed used	Germination	Marketable tuber		Significance of difference
		Weight	Difference	
	Per cent	*Kilo*	*Kilo*	
Imported seed from Japan (control)	96.1	13.5±0.60	.....	.....
Baguio-grown (crated and stored in a room)	69.0	2.4±0.25	—11.1±0.65	Significant.
Baguio-grown (crated and buried under a building)	69.1	3.5±0.20	—10.0±0.63	Do.

The methods of storing seed potatoes that were employed, namely, (*a*) in crates in an ordinary room, and (*b*) in crates buried under a building, were not found satisfactory under Baguio conditions even for a period of four months only. In the former method, the tubers germinated and produced long, slender shoots, and the tubers themselves became shriveled and very soft. In the second method, all the tubers also produced too long shoots, though they remained hard and seemed fairly suitable for planting purposes.

As seen in Table 7, the seed-tubers stored under both methods were very much inferior to the imported seed of the same variety. The percentage of germination was very low, and even most of those that germinated produced weak plants. It may be remarked in passing, however, that there were a few plants from the Baguio-grown seed that were comparable to the best from the imported seed. So that it may yet be assumed that the inferior producing power of the Baguio seed was mainly due to the fact that it was greatly devitalized because of early germination in storage long before the planting season. So as not to have to store for long periods, some studies are now being undertaken in parts of the Islands where the climatic conditions are favorable to the growing of potatoes during the month of June and July, to produce seed tubers during the general planting season in November to February. Recent reports give the information that a good potato crop has been obtained at Panubigan, Occidental Negros, from a trial made in July, 1933.

Of the two methods of storing employed, burying the seed-tubers in dry ground under a building was better than storing in an ordinary room. The plants obtained from the former set of seed were stouter and yielded about 46 per cent more than the latter.

SUMMARY OF CONCLUSIONS

From the results presented in this paper, the following conclusions seem justified:

1. The best time to plant Irish potatoes in Baguio and in Trinidad Valley, Mountain Province, is between December 15 and January 15. Provided adequate irrigation water is available, a fair crop can be obtained by planting as late as February 15.

2. All the plots treated with a 9–12–9 commercial fertilizer gave greater average yields than the check plots; the increase in yield was more or less proportional to the amount of fertilizers applied. The plots treated at the rate of 450 and 700 kilos per hectare gave an increase of 74 and 89 per cent, respectively, in marketable tubers over the unfertilized plots.

3. The size of the marketable tubers was affected by the amount of fertilizer applied. It was evident that the tendency was towards bigger tubers in plots receiving heavier applications of fertilizer. The average weights of tubers from the different treatments were 64.3 $\pm$ 1.62, 70.8 $\pm$ 1.93, 80.9 $\pm$ 2.40 and 87.5 $\pm$ 2.77 grams for the control (unfertilized), and the 200-, 450-, and 700-kilo rate per hectare, respectively.

4. The Japanese Red produced fewer but bigger tubers and yielded slightly more per unit area than the Japanese White. On the other hand, the Japanese White had better keeping and eating qualities than the former. Taking all points together the latter variety (Japanese White) is the better for commercial planting. The superior keeping quality of the Japanese White alone more than offsets the higher yielding power of the Japanese Red.

5. Storing Baguio-grown potatoes for seed in a room or in a pit under a building was not successful. The tubers thus stored germinated long before the planting season, thus they were inescapably devitalized; when they were planted, they were very much inferior to fresh imported seed from Japan in growth and in yielding power. The presence, however, of a few plants that compared favorably in stand and yield with the imported plants showed the potential value of home-grown seed if properly stored.

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ILLUSTRATIONS

Plate I

Fig. 1. Showing the characteristic arrangement of the tubers at the base of the plants. Japanese White. Note how the tubers are clustered together at the base.

2. Showing the characteristic arrangement of the tubers at the base of the plants. Japanese Red. The tubers are few, and are formed away from the base.

PLATE I

CHEMICAL CHANGES OCCURRING DURING THE SALTING OF CHICKEN AND DUCK EGGS UNDER DIFFERENT TREATMENTS

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FOUR TEXT FIGURES

The rôle of salt in the preservation of foods, especially meat and fish products, has been known for a long time. In fact salt was one of the first known materials for preserving meat and fish. In China and in the Philippines, salt is also employed for preserving eggs. While there is no record to show how extensive the salting of eggs is in the Philippines, it must be a thriving business judging from the number of salted duck eggs sold everywhere. Table I, prepared by the Division of Statistics of the Department of Agriculture and Commerce, shows that the Philippines are importing nearly 400,000 dozen preserved eggs from China, a large proportion of which are salted.

Salted duck eggs are commonly sold throughout the Philippines. They are sold at from 2.80 to 2.90 pesos[3] per hundred, while fresh duck eggs are sold at from 2.30 to 2.40 pesos per hundred. Salted eggs are boiled and then dyed magenta, and they usually remain in the stores many days and even weeks before they are sold and eaten; hence, quite frequently one opens an egg and finds it spoiled. Moreover, eggs sold in the stores are not as fine flavored and wholesome as the home-made ones, which can be prepared easily.

Literature on the subject is conspicuous for the absence of reported chemical study of preparing salted eggs. It is the purpose of this paper to report the results of a preliminary study of the chemical changes occurring during the salting of eggs.

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[2] Formerly Assistant in Chemistry of the College of Agriculture, University of the Philippines.

[3] One peso Philippine currency equals 50 cents United States currency.

There are several methods of preserving eggs. Those commonly used in America and Europe are low temperature storage and the exclusion of air by the use of oil and water glass (Na_2SiO_3). The use of salt is extensive in the Orient. In the Philippines the eggs are coated with a clean, sticky clay to which plenty of salt has been added, the commonest proportion being one part of salt to four or five parts of clay. Another method is to place the eggs in a cold saturated solution of table salt. In East India, according to Wang [4] (1929), duck eggs are often preserved by packing them in a mixture of clay, brick-dust, and salt for two or three months. In China several methods of preserving eggs are used. Duck eggs are often buried in the ground for ten to twelve months. Eggs thus preserved undergo a peculiar fermentation. The hydrogen sulphide produced breaks the shell and escapes, while the eggs become hard in texture. The process completed, the product has no disagreeable odor or taste. Eggs are also preserved in a mixture of salt and cooked rice to which wort has been previously added. The eggs are stored for six months or longer, and by the time they are ready for market the shells have been dissolved or completely softened and the inner membrane greatly thickened. The egg is somewhat coagulated. It looks like a soft-boiled egg, but it has a strong winelike taste and smell.

Another kind of preserved eggs found in China is the so-called "hilidan" eggs. The eggs are immersed in a saturated cold solution of common salt and after a month or more they are eaten hard-boiled. In some parts of China a mixture of salt, sea earth or wood ashes, and water is used. The eggs—duck eggs usually—are carefully washed and then covered one by one with this mixture. They are then packed in jars and stored away for about a month. Still another kind of preserved duck egg found in China is the so-called "Pidan," the famous century eggs of China. The method employed in its preparation is as follows: One and one-third pounds of strong black tea is made. Into this infusion, 9 pounds of lime and 4.5 pounds of common salt are put and finally, about 32 quarts of freshly burned wood ashes is added. The best quality duck eggs are first cleaned and then one by one carefully and evenly covered with the mixture. They are then stored for a period of

[4] Wang, Chi Che, U. S. Egg and Poultry Mag. (October, 1929).

five months. At the end of this period they are taken out and covered fully a quarter of an inch deep with rice hulls. The eggs are then ready for the market.

MATERIALS AND METHODS

Fresh chicken and duck eggs were used in this study. Forty chicken eggs were placed in a 10 per cent salt (NaCl) solution and another 40 were placed in a saturated salt solution. Five eggs in the fresh state were boiled hard, separated into the different parts (shell, white, and yolk) and each part was weighed and sampled for analysis. These served as the control. Every five days, five eggs were taken from each lot. The eggs were then weighed, separated into the different parts in the same way as just described, sampled, and analyzed.

Fresh duck eggs were also used, but in place of the 10 per cent salt solution a soil-salt mixture of equal parts by volume of air-dried soil from a termite hill or mound and salt were used. After the soil and salt were thoroughly mixed, a sufficient amount of water was added to form a thick paste. The duck eggs, which had been well washed, were placed in this soil-salt paste. Ten duck eggs were analyzed for control. Every five days, ten eggs were taken from each lot and analyzed in the same way as the chicken eggs.

METHODS OF ANALYSIS

The samples (shell, white or albumen, and yolk) were analyzed for moisture, ash, and sodium chloride by the methods adopted by the Association of Official Agricultural Chemists (1925).

RESULTS AND DISCUSSIONS

The results of this study are given in Tables 2 to 7 and text figs. 1 to 4.

The behavior of the eggs under the different treatments did not vary greatly. Examination of the tables and graphs will show, for example, that the percentage of shell in the egg tended to increase somewhat, but not greatly. The apparent increase in the percentage of shell in the egg seems to have been due to the changes in moisture and sodium chloride content. In the case of chicken eggs, for example, there was a drop of moisture in the first week. Thereafter, with eggs treated in saturated brine,

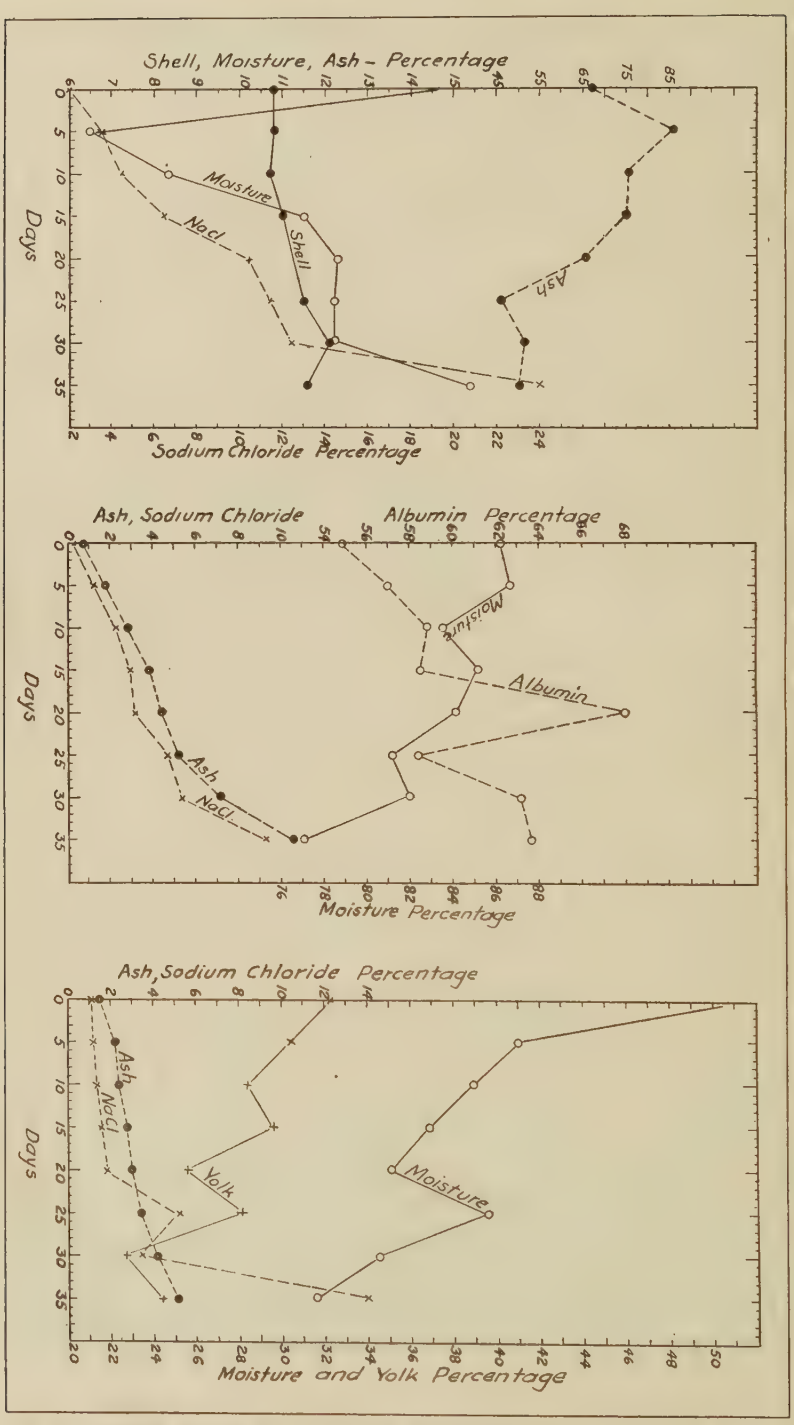

FIG. 1. Chemical changes in chicken eggs during salting in saturated salt solution

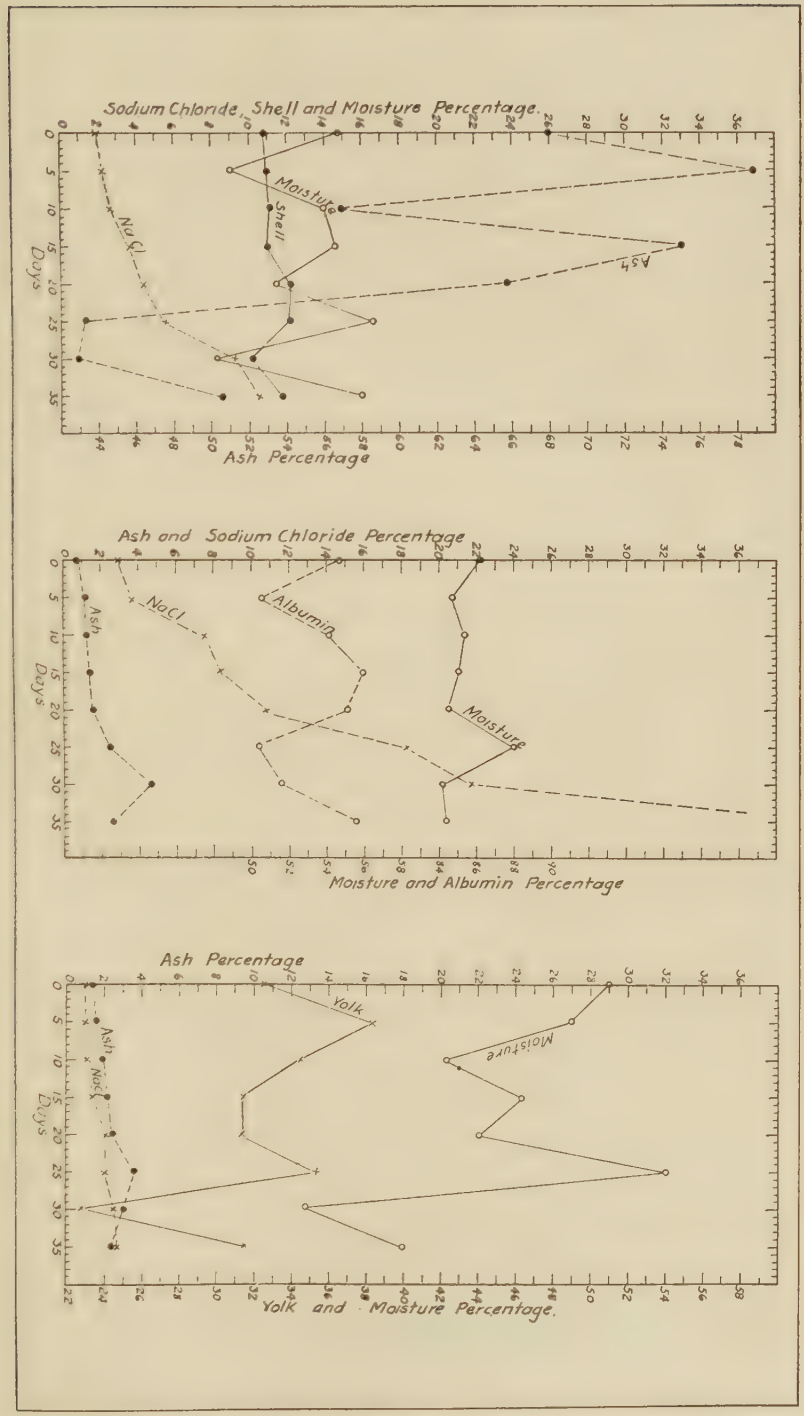

FIG. 2. Chemical changes in chicken eggs during salting in 10 per cent salt solution

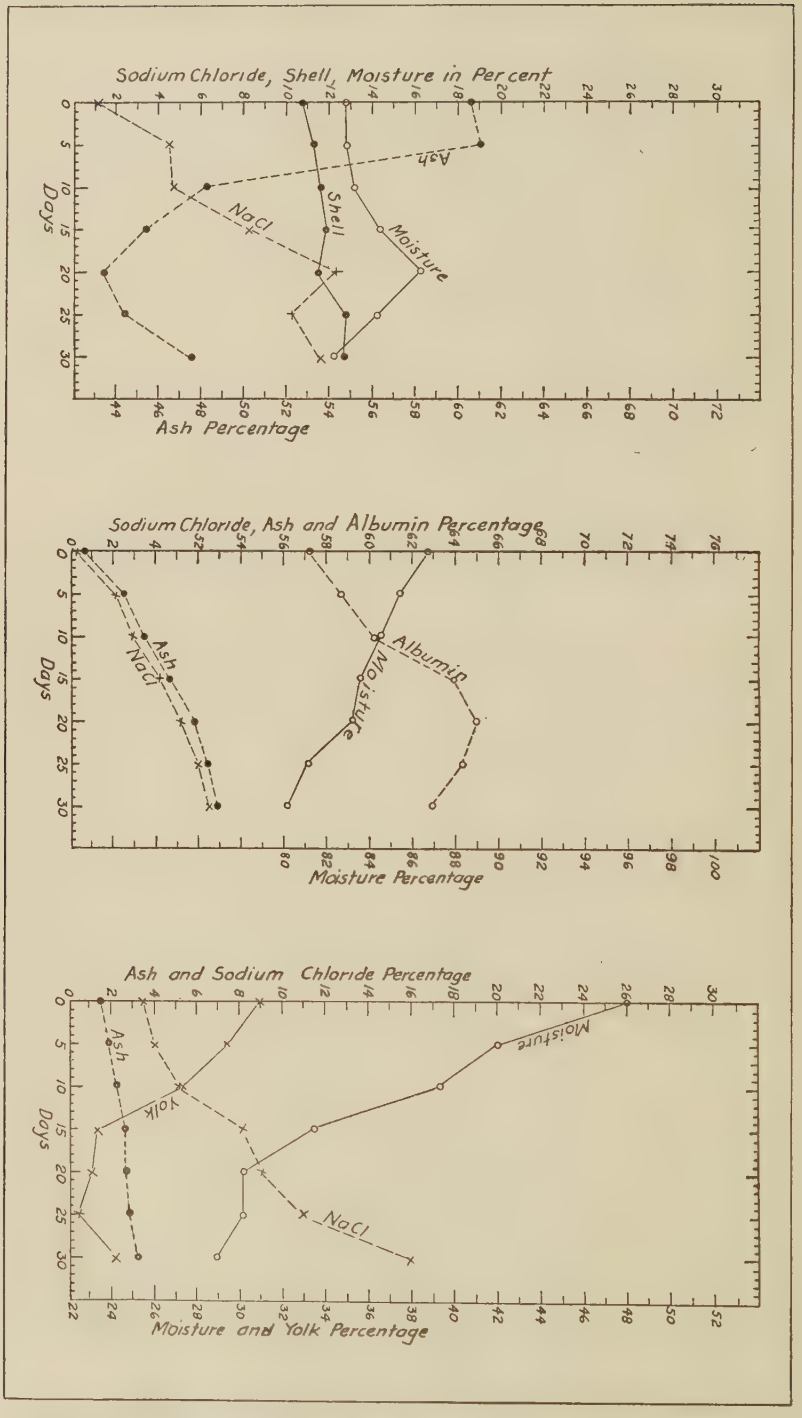

FIG. 3. Chemical changes in duck eggs during salting in saturated salt solution

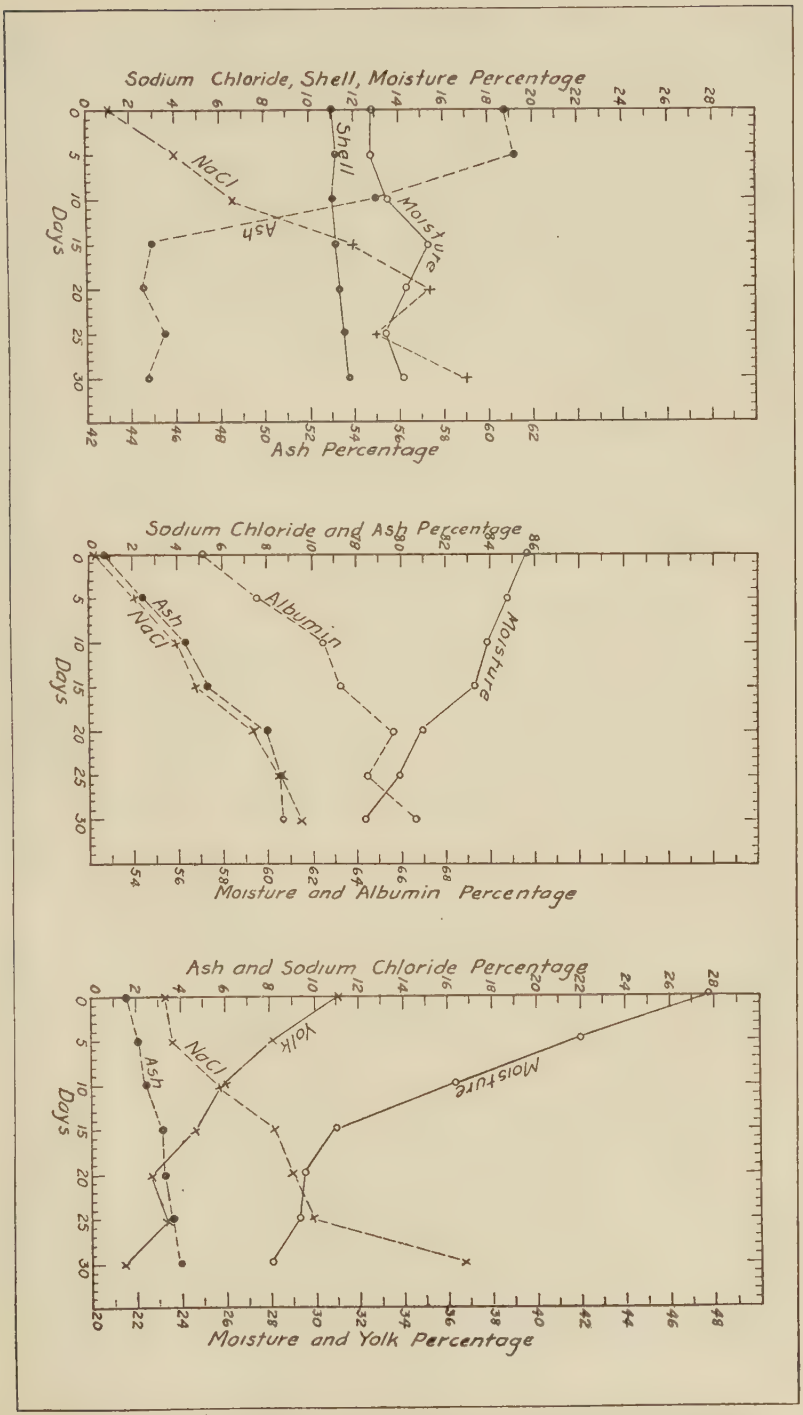

FIG. 4. Chemical changes in duck eggs during salting in soil-salt mixture

there was an increase of moisture above the initial value (Table 2 and text fig. 1). The moisture of shell in chicken eggs treated with a 10 per cent salt solution showed an uneven behavior, but the tendency was also towards an increase. With duck eggs, the increase in moisture continued until the second and fourth weeks, after which the moisture content dropped.

In all cases, the sodium chloride content of the shell increased. This increase may have been due to the absorption of sodium chloride by the shell. Thus it will be seen that in all cases the ash content of the shell increased during the first five days, due to the incorporation of sodium chloride in the shell, then decreased greatly thereafter until the twentieth or twenty-fifth day, after which there was a tendency to increase again.

There was an increase in the percentage of albumin in the egg in the chicken and duck eggs treated with saturated salt solution, and in duck eggs preserved in soil-salt mixture. With the chicken eggs in 10 per cent salt solution, the albumen in the eggs varied between 50 and 56 per cent, but the initial and final values were almost the same, about 55 per cent. In the first three cases the increase in albumen in the eggs was evidently due to the absorption of salt by the albumen portion, as shown by a steady increase in the sodium chloride content and also by the consistent increase in ash, paralleling the increase in sodium chloride. The incorporation of sodium chloride in the albumen decreased the relative proportion of moisture in the albumen. With the chicken eggs treated with a 10 per cent salt solution, there was an unusual increase in sodium chloride, possibly due to the effect of dilution. The increase in salt increased the percentage of ash in the albumen. The increase in salt in the albumen in chicken eggs in saturated salt and duck eggs in saturated salt and soil-salt mixture was from 5 to 10 per cent, while that in chicken eggs in a 10 per cent salt solution was about 40 per cent.

It may be seen that, in all cases, the percentage of yolk in the eggs decreased. It may also be seen that the decrease in yolk in the eggs may have been due to the loss in moisture in the yolk, the curves representing the loss in yolk and moisture in the yolk as parallel to each other. In this manner, the preserving media may be thought of as a dehydrating agent, withdrawing moisture from both the albumen and yolk, and apparently from the shell also.

In the case of the chicken eggs, there was an increase in the ash. In the case of the duck eggs, however, the increase in the sodium chloride was very much greater than the increase in the ash for the same period. During the same period the duck eggs absorbed more salt from a surrounding salt solution than chicken eggs. This may explain why duck eggs are generally used for preparing salted eggs.

Regarding the proximate chemical composition of treated duck eggs, it may be seen from Tables 5 and 7 that the percentage of protein of the albumen did not show conspicuous changes and the gain in ash was approximately equal to the loss in moisture.

In the yolk, the total gain in percentage of protein, crude fats, and ash seemed to be nearly equal to and compensate for the loss in moisture. There seemed to be no material change in food value, excepting that the decrease in moisture produces a concentration of these food constituents.

In general it may be seen that although the shell did not change under the various treatments, the sodium chloride of the shell increased as treatment was prolonged, while the ash of the shell decreased to and remained at a certain value. The increase in the sodium chloride and ash content of the albumen was roughly proportional to the duration of treatment. The yolk lost moisture and weight but gained in sodium chloride and ash.

SUMMARY

1. To find the chemical changes occurring during the salting of eggs, fresh chicken eggs were treated with saturated and 10 per cent salt solutions, and duck eggs with saturated salt solution and soil-salt mixture. Periodic analyses of representative samples were made.

2. The percentage of shell in the treated eggs remained more or less constant, the percentage of albumen increased and the percentage of yolk decreased.

3. There was an increase of sodium chloride in the shell, the albumen, and the yolk and an increase of ash in the albumen and the yolk, but a decrease of ash in the shell.

4. The absorption of salt by the yolk was more pronounced in the duck eggs than in the chicken eggs.

5. There was relatively no change in the protein and fat content of both the albumen and yolk, the apparent increases being due to a relative decrease in moisture.

TABLE 1.—*Annual imports of eggs into the Philippines by countries of origin*

Countries of origin	1931		1932	
	Dozens	Pesos	Dozens	Pesos
Eggs in natural form:				
Hen—[a]				
United States	13,797	7,811	15,799	9,007
China	4,780,467	886,170	4,330,333	634,968
British East Indies	31	8	.....	.....
Japan	145,674	59,686	156,922	33,654
Australia	330	179	.....	.....
Total	4,940,299	953,854	4,503,054	677,629
Other fresh eggs—[a]				
British East Indies	6,432	383	15,475	778
Preserved eggs—[a]				
China	404,458	96,484	334,278	64,212

[a] Not separately classified prior to 1931.

TABLE 2.—*The chemical changes occurring during the salting of chicken eggs in saturated salt solution*

Treatment	Shell				Albumen				Yolk			
	Shell	Moisture	Ash	Na Cl	Albumen	Moisture	Ash	Na Cl	Yolk	Moisture	Ash	Na Cl
	P. ct.	*P. ct.*	*P. ct.*	*mg per 100 g.*	*P. ct.*	*P. ct.*	*P. ct.*	*mg per 100 g.*	*P. ct.*	*P. ct.*	*P. ct.*	*mg per 100 g.*
Untreated	10.85	14.88	68.02	203	54.93	86.26	0.75	304	32.25	50.99	1.49	111
After 5 days	10.89	6.53	86.08	363	57.05	86.74	1.85	1,154	30.52	41.09	2.18	117
After 10 days	10.71	8.25	76.25	447	58.99	83.62	2.93	2,281	28.44	38.90	2.28	126
After 15 days	11.04	11.54	75.41	654	58.53	85.19	3.92	3,017	29.57	36.92	2.84	162
After 20 days		12.25	66.89	1,051	68.05	84.23	4.36	3,113	25.57	35.25	2.96	176
After 25 days	11.51	12.16	47.38	1,145	58.42	81.23	5.21	4,699	28.22	39.64	3.30	522
After 30 days	12.11	12.18	53.47	1,248	63.22	82.08	7.24	5,360	22.71	34.47	4.11	337
After 35 days	11.58	15.43	50.08	2,413	63.58	77.54	10.63	9,309	24.67	31.67	5.12	1,419

TABLE 3.—*The chemical changes occurring during the salting of chicken eggs in 10 per cent salt solution*

Treatment	Shell				Albumen				Yolk			
	Shell	Moisture	Ash	Na Cl	Albumen	Moisture	Ash	Na Cl	Yolk	Moisture	Ash	Na Cl
	P. ct.	*P. ct.*	*P. ct.*	*mg per 100 g.*	*P. ct.*	*P. ct.*	*P. ct.*	*mg per 100 g.*	*P. ct.*	*P. ct.*	*P. ct.*	*mg per 100 g.*
Untreated	10.85	14.88	68.02	203	54.93	86.26	0.75	304	32.25	50.99	1.49	111
After 5 days	11.00	8.99	78.79	229	50.56	84.71	1.23	368	38.38	48.97	1.57	114
After 10 days	11.05	14.25	56.98	270	54.16	85.35	1.26	760	34.40	42.25	2.09	122
After 15 days	11.04	14.68	75.05	371	56.08	85.24	1.42	846	31.48	46.26	2.23	146
After 20 days	12.30	11.53	65.75	444	55.18	84.59	1.62	1,082	31.47	43.87	2.46	218
After 25 days	12.16	16.56	43.38	561	50.43	87.95	2.47	1,828	35.27	54.02	3.56	211
After 30 days	10.11	8.29	43.00	929	51.59	84.23	4.65	2,179	22.88	34.79	3.20	264
After 35 days	11.82	16.08	50.58	1,059	55.73	84.28	2.65	4,060	31.52	40.00	2.44	271

TABLE 4.—*The chemical changes occurring during the salting of duck eggs in saturated salt solution*

Treatment	Shell				Albumen				Yolk			
	Shell	Moisture	Ash	Na Cl	Albumen	Moisture	Ash	Na Cl	Yolk	Moisture	Ash	Na Cl
	P. ct.	*P. ct.*	*P. ct.*	*mg per 100 g.*	*P. ct.*	*P. ct.*	*P. ct.*	*mg per 100 g.*	*P. ct.*	*P. ct.*	*P. ct.*	*mg per 100 g.*
Untreated	10.92	12.87	60.68	119	57.17	86.76	0.66	428	31.13	47.85	1.50	346
After 5 days	11.22	12.87	60.98	447	58.71	85.50	2.46	2,265	29.47	41.96	1.80	388
After 10 days	11.56	13.08	48.28	470	60.30	84.60	3.48	3,852	27.41	39.39	2.21	510
After 15 days	11.85	14.42	45.38	830	64.01	83.67	4.68	4,151	23.28	33.53	2.76	823
After 20 days	11.48	16.31	43.40	1,245	65.11	83.30	5.75	5,177	23.14	30.15	2.75	887
After 25 days	12.91	14.20	44.43	1,025	64.41	81.12	6.42	5,898	22.43	30.15	2.68	1,104
After 30 days	12.71	12.14	47.63	1,160	62.96	80.32	6.90	6,504	24.13	29.09	3.11	1,607

TABLE 5.—*The chemical changes occurring during the salting of duck eggs in saturated salt solution*

Treatment	Albumen				Yolk			
	Moisture	Protein N x 6.25	Fat-ether extract	Ash	Moisture	Protein N x 6.25	Fat-ether extract	Ash
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Untreated	86.76	11.05	Trace	0.66	47.85	16.95	32.04	1.50
After 5 days	85.50	10.50	do.	2.46	41.96	18.36	36.12	1.80
After 10 days	84.64	11.06	do.	3.48	39.39	18.72	40.15	2.21
After 15 days	83.67	10.45	do.	4.68	33.53	20.44	43.28	2.76
After 20 days	83.30	9.65	do.	5.75	30.15	21.00	46.06	2.75
After 25 days	81.12	10.74	do.	6.42	30.15	19.21	47.00	2.68
After 30 days	80.32	10.00	do.	6.90	29.09	20.98	46.79	3.11

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TABLE 6.—*The chemical changes occurring during the salting of duck eggs in soil-salt mixture*

Treatment	Shell				Albumen				Yolk			
	Shell	Moisture	Ash	Na Cl	Albumen	Moisture	Ash	Na Cl	Yolk	Moisture	Ash	Na Cl
	P. ct.	*P. ct.*	*P. ct.*	*mg per 100 g.*	*P. ct.*	*P. ct.*	*P. ct.*	*mg per 100 g.*	*P. ct.*	*P. ct.*	*P. ct.*	*mg per 100 g.*
Untreated	10.92	12.87	60.68	119	57.17	86.76	0.66	428	31.13	47.85	1.50	346
After 5 days	11.19	12.83	61.30	389	59.66	84.95	2.54	2,233	28.24	41.85	2.11	371
After 10 days	11.06	13.47	55.02	656	62.74	84.04	4.35	4,139	25.87	36.39	2.38	580
After 15 days	11.19	15.26	44.85	1,203	63.29	83.52	5.39	4,976	24.79	31.00	3.09	829
After 20 days	11.26	14.38	44.59	1,548	65.68	81.09	8.02	7,380	22.79	29.60	3.28	891
After 25 days	11.48	13.30	45.50	1,305	64.52	79.92	8.49	8,452	23.38	29.44	3.64	1,000
After 30 days	11.73	14.21	44.75	1,750	66.64	78.35	8.73	9,512	21.48	28.03	3.95	1,680

TABLE 7.—*The chemical changes occurring during the salting of duck eggs in soil-salt mixture*

Treatment	Albumen				Yolk			
	Moisture	Protein N x 6.25	Fat-ether extract	Ash	Moisture	Protein N x 6.25	Fat-ether extract	Ash
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Untreated	86.76	11.05	Trace	0.66	47.85	16.95	32.04	1.50
After 5 days	84.95	9.72	do	2.54	41.85	17.85	36.45	2.11
After 10 days	84.04	10.36	do	4.35	36.39	20.36	40.24	2.38
After 15 days	83.52	8.82	do	5.39	31.00	20.39	44.85	3.09
After 20 days	81.09	8.73	do	8.02	29.60	21.35	45.52	3.28
After 25 days	79.92	9.89	do	8.49	29.44	21.32	45.43	6.64
After 30 days	78.35	10.93	do	8.73	28.03	21.53	45.61	3.95

ILLUSTRATIONS

TEXT FIGURES

FIG. 1. Chemical changes in chicken eggs during salting in saturated salt solution.
2. Chemical changes in chicken eggs during salting in 10 per cent salt solution.
3. Chemical changes in duck eggs during salting in saturated salt solution.
4. Chemical changes in duck eggs during salting in soil-salt mixture.
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